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Studies on external genitalia of *Mangina syringa* (Cramer) (Lepidoptera: Erebidae: Arctiinae)

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ABSTRACT: External male and female genitalia of *Mangina syringa* (Cramer) is described and illustrated in detail. A key to the Indian species of genus *Mangina* Kaleka & Kirti has also been given. © 2013 Association for Advancement of Entomology

KEYWORDS: Lepidoptera, Erebidae, Arctiinae, *Mangina syringa* (Cramer), external genitalia.

INTRODUCTION

Originally, *Mangina syringa* Cramer was described under genus *Phalaena* (Cramer, 1775). Hampson (1894) transferred it to genus *Argina* Hübner and recently Dubatolov (2010) catalogued *syringa* Cramer under genus *Mangina* Kaleka & Kirti, 2001. The external male genital attributes like size of vinculum, weakly developed saccus, shape of cucullus and valvula and female genital attribute like presence of signum makes *syringa* Cramer congeneric with the type of *Mangina* Kaleka and Kirti, a genus known by three species, ‘with two of them’ *M. argus* (Kollar) and *M. syringa* (Cramer) from India. The present manuscript relates to the details of external male and female genitalia of *M. syringa* collected from different localities in the Western Ghats of India. A key to both the Indian species has also been given in this communication.

MATERIALS AND METHOD

The moths were collected, preserved and studied using standard techniques in lepidopterology. For the preparation of permanent slides of fore and hind wings, the method

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proposed by Common (1970) and advocated by Zimmerman (1978) has been followed. For the study of external genitalia, methodology given by Robinson (1976) has been followed. The diagrams of genitalia were drawn with the help of a graph eye piece fitted in a stereo zoom binocular, on graph papers. Multiple dissections of the studied species were made to examine any population variations. The terminology given by Klots (1970) has been followed in the present studies for nomenclatural purpose.

RESULTS AND DISCUSSION

Genus *Mangina* Kaleka & Kirti

Kaleka & Kirti 2001, J. Bomb. Nat.Hist.Soc.98 (2): 250.

Type species: *Argina argus* Kollar.

Distribution: India, Pakistan, Sri Lanka, Burma, Bhutan, Nepal, Indochina, China, Taiwan, Japan, Philippines.

Diagnosis: Labial palpi upturned. Antennae simple in both sexes. Forewing with vein R_3 and R_4 anastomoses to form a long areole; M_1 from upper angle of cell; M_2 , M_3 and Cu_1 near lower angle of cell. Hindwing with vein $Sc+R_1$ originating towards base of cell; Rs and M_1 from upper angle of cell; in males tornus produced acutely and bears an elongated patch of dark scales. Male genitalia with uncus long, tip pointed; acrotergite absent; fenestrula present; saccus weakly developed; valvae long and narrow, costa produced to a plough like structure; aedeagus long, vesica membranous with suffusion of small denticles, ductus ejaculatorius entering laterally. Female genitalia with corpus bursae membranous, signum present.

***Mangina syringa* (Cramer)**

Phalaena syringa Cramer, 1775, Pap. Exot., 1 : 5.

Deiopeia syrigna (Cramer); Walker 1854, Cat. Lep. Het. B.M., 2: 572.

Argina syringa (Cramer); Hampson 1894, Fauna Br. Ind. Moths, 2 : 51.

Mangina syringa (Cramer); Dubatolov 2010, Neue Entomologische Nachrichten, 65: 1-106

Male genitalia: Uncus long and moderately broad, horn-bill beak shaped, setosed with minute setae, uniformly sclerotized, gradually ends to a pointed tip; acrotergite absent; fenestrula triangular; tegumen longer than uncus, v-shaped; vinculum shorter than tegumen, u shaped, narrow, uniformly sclerotized; saccus weakly developed. Valvae long and narrow; costa produced to a plough like structure, sclerotized, slightly wavy; sacculus well defined, produced to an outgrowth towards proximal end, folded; cucullus and valvula not differentiated; tip of valvae pointed and produced to a snout like structure, sparsely setosed with short setae.

Transtilla membranous; juxta triangular plate like; aedeagus long and broad, slightly wavy, series of small spines at distal end; vesica membranous with patches of sclerotized spots; ductus ejaculatorius entering laterally (Plate 1).

Female genitalia: Corpus bursae bilobed, membranous, single signum present; ductus bursae short, sclerotized; ductus seminalis entering corpus bursae; anterior apophyses shorter than posterior apophyses; papilla anales covered with short setae.

Wing span: Male 56-64 mm; female 60-64 mm.

Material Examined

Maharashtra	:	Mahabaleshwar (1320 m), 29.xi.04 – 3 m, 30.xi.04 – 5 m, 1.xii.04 - 2♂ 1f, 8.x.05 – 4♂; Amboli (850 m), 10.x.05 – 4♂.
Goa	:	Keri (90 m), 25.ii.04 – 1♂.
Karnataka	:	Medikeri (1100 m), 23.xi.03 – 2♂.
Kerala	:	Devikulam (1620 m), 13.ix.04 – 1 f, 14.ix.04 – 1♂.
Tamil Nadu	:	Kodai Kanal (2133 m), 19.iv.03 – 1♂; Doddabeta (2640 ♂), 1.x.03 – 1 m; Kotagiri (2020 m), 22.xi.05 – 2♂ 2♀; Kodanadu (1920 ♂), 26.xi.05 – 1♂.

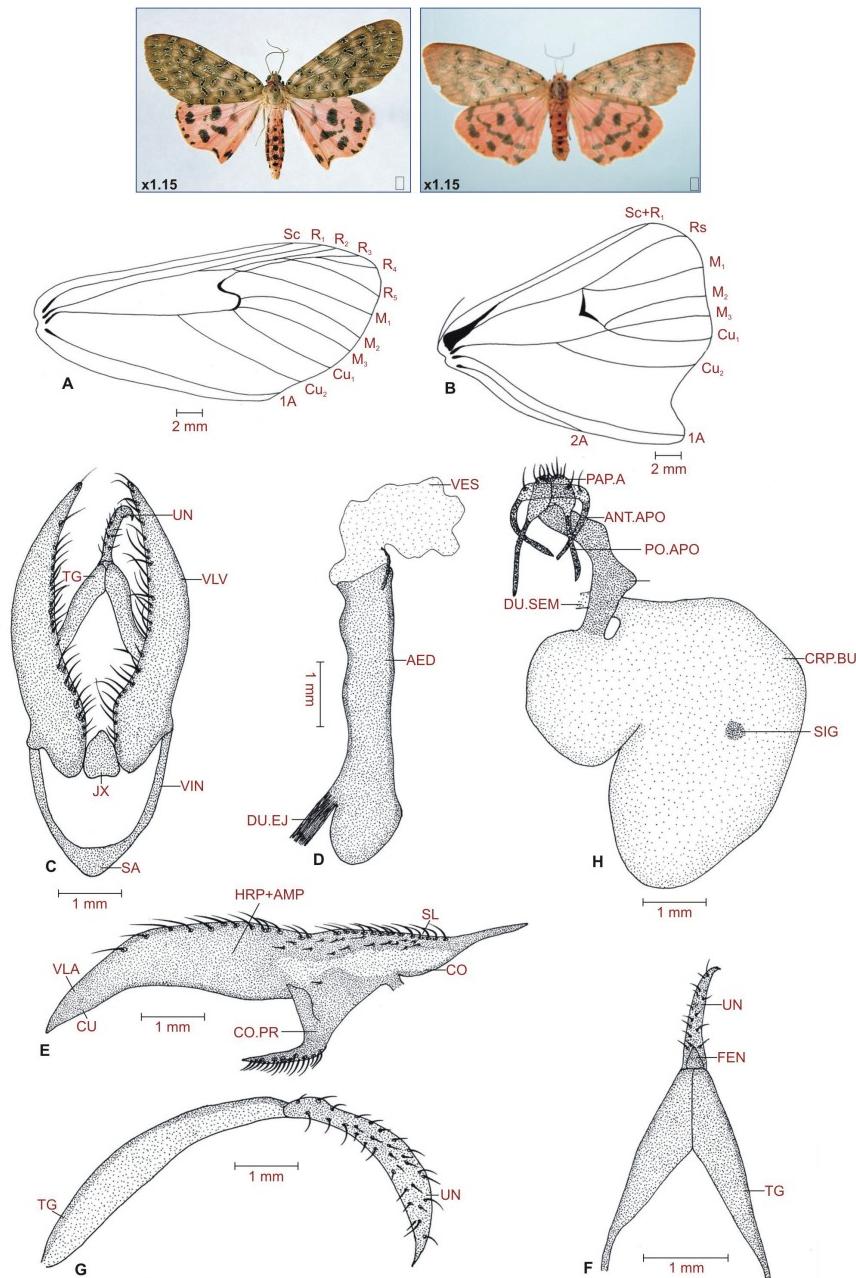
Distribution: India, Sri Lanka.

Key to the Indian species of genus *Mangina* Kaleka and Kirti

1. Forewing with ground colour ferruginous; vein Cu₂ beyond middle of cell; hindwing with vein M₂ and M₃ from lower angle; Cu₁ before angle of cell; male genitalia with fenestrula rounded; tip of valvae bifurcated; female genitalia with a pair of semicircular signa..... *M. argus* (Kollar)
2. Forewing with ground colour brown; vein Cu₂ originating from middle of cell; hindwing with vein M₂ beyond lower angle; M₃ and Cu₁ from angle of cell; male genitalia with fenestrula triangular; tip of valvae pointed; female genitalia with single signum..... *M. syringa* (Cramer)

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The authors are grateful to Department of Science and Technology (DST), Govt. of India, New Delhi for providing financial support in form of a project entitled “Taxonomic revision of



(Figs.A- H): *Mangima syringa* (Crammer):

A - Forewing, B - Hind wing, C - Male genitalia, D - Aedeagus, E - Valvae (inner view), F - Tegumen and Uncus (dorsal view), G - Tegomen and Uncus (lateral view), H - Fenake genitalia

Indian Arctiidae (Lepidoptera)". We are thankful to The Director, Zoological Survey of India for providing necessary facilities. Thanks are also due to all the PCCFs, DFOs & other staff of forest departments of different states encompassing the Western Ghats who cooperated for the collection of *M. syringa*.

ABBREVIATIONS

1A : First anal vein ; 2A : Second anal vein; AED : Aedeagus; AMP+HRP : Ampulla & Harpe (fused); ANT.APO : Anterior apophyses; CO : Costa; CO.PR : Costal process; CRP.BU : Corpus bursae; CU : Cucullus; CU₁ : First cubital vein; CU₂ : Second cubital vein; DU.EJ : Ductus ejaculatorius; DU.SEM. : Ductus seminalis; FEN : Fenestrula; JX : Juxta; M₁ : First median vein; M₂ : Second median vein; M₃ : Third median vein; PAP.A : Papilla anales; PO.APO : Posterior apophyses; R₁ : First radial vein; R₂ : Second radial vein; R₃ : Third radial vein; R₄ : Fourth radial vein; R₅ : Fifth radial vein; RS : Radial Sector; SA : Saccus; SC : Subcosta; SC+R₁ : Stalk of SC + R₁; SIG : Signum; SL : Sacculus; TG : Tegumen; UN : Uncus; VES : Vesica; VIN : Vinculum; VLA : Valvula; VLV : Valva.

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Biosystematic study of the Satyrinae (Lepidoptera: Nymphalidae) fauna of Kerala, India

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ABSTRACT: A general survey was carried out on the Satyrine fauna of the Kerala Western Ghats recording 27 species compared to 29 species recorded from the Western Ghats. External genitalial morphology of fourteen species under 6 genera was studied. Based on an evaluation of resemblances of the genital parts, particularly of the valvae, uncus and phallus of the male external genitalia, these species were categorised under two separate groups. The first group contained *Melanitis leda*, *Melanitis (phedima) varaha*, *Mycalesis anaxias*, *Mycalesis oculus*, *Lethe (drypetis) todara*, *Lethe (rohria) neelgheriensis* and *Zipaetus saitis*. Of these, *Mycalesis anaxias*, *Mycalesis oculus* and *Lethe (rohria) neelgheriensis* formed a subgroup distinct from the others. The second group contained *Mycalesis (perseus) tabitha* and *M. igilia*. These species shared resemblance with *Lethe rohria*, *Mycalesis oculus*, *Mycalesis (perseus) tabitha*, *Mycalesis subdita*, *Mycalesis igilia* and *Mycalesis adolphei*. Each of the remaining species viz., *Mycalesis (Patnia) junonia*, *Mycalesis subdita* and *Ypthima (baldus) madrasa* showed distinctness in their identity. Among these, *Y. (baldus) madrasa* stood out separately from all the rest. The study shows the heterogeneity of taxa included under the various satyrine genera suggesting the need for a detailed taxonomic revision of the group. Information generated in this study has also shown very good survival of most of the satyrine species in the Kerala part of the Western Ghats mainly due to protection of the natural habitats.

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KEYWORDS: External genital morphology, Butterflies

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INTRODUCTION

Satyrids are shade loving butterflies generally confined to thick evergreen forests. They prefer to remain in cool, dense vegetation, seldom venturing out in the open. They are usually dull-colored, brown or blackish brown butterflies and are popularly known as Browns. The wings have characteristic eye spots (ocelli) and white or tawny bands. Their flight is weak and jerky, keeping close to ground level and flying to a short distance. They have a definite preference for sap exuding from trees, toddy and rotting fruits lying on the forest floor. Excepting *Elymnias* spp. which feed on palms, the immature stages of almost all species develop on grasses or bamboos.

Studies on the Indian satyrids have been made by Ferguson (1891), Moore (1891, 1892 & 1893), Sevastopulo (1973), Evans (1932), Talbot (1947), Wynter-Blyth (1957), D'Abrera (1985), Ackery (1988), Larsen (1988), Sathyamurthy (1994), Gaonkar (1996), Mathew (1999), Kehimkar (2008), Kunte (2000), Ghorpade and Kunte (2010) and Ghosh (1914). Classification of this family is based mainly on the wing venation at higher taxonomic levels and on colour and wing pattern at species level. However, many species exhibit seasonal or habitat linked variations in colour patterns rendering identification difficult.

The significance of the morphological details of the external genitalia in resolving the taxonomic identities is well recognized (Miller, 1968). Recently, Sharma and Rose (1999) segregated *kalinda* Moore and *shallada* Marshall & de Niceville of the genus *Paralasa* Moore based on the structural details of the external genitalia. The Satyrine butterflies found in the forests of Kerala show considerable variations in response to season or habitat. It was in this context that the present study on the morphological details of the external genitalia was undertaken to confirm their taxonomic identities and the findings are presented in this paper.

MATERIALS AND METHOD

Samples of butterflies required for the morphological and taxonomical studies were collected by conducting a field survey in the Kerala part of the Western Ghats. The locations covered in this study included Peechi-Vazhani, Vazhachal, Palappilly, Sholayar, Kattlapara, Nelliampathy Malayattoor, Thattakkad, Kothamangalam, Rajmala, Thenmala, Wynad, Parambikulam, Rockwood, Pandimatta, Muthanga, Wayanad and Chembra peak. The specimen are deposited at the KFRI, Peechi

RESULTS

Checklist of Satyrinae of Kerala:

1. *Elymnias caudata* Butler
2. *Letha europa* Fabricius
3. *Letha (drypetis) todara* Moore

4. *Lethe (rohria) neelgheriensis* (Guerin-Meneville)
5. *Melanitis leda* Linnaeus
6. *Melanitis (zitennius) gokala* Moore
7. *Melanitis (phedima) varaha* Moore
8. *Mycalesis adolphei* Guerin-Meneville
9. *Mycalesis anaxias* Hewitson
10. *Mycalesis igilia* Fruhstorfer
10. *Mycalesis igilia* Fruhstorfer
11. *Mycalesis (khasia) orcha* Evans
12. *Mycalesis davisoni* Moore
13. *Mycalesis (mineus) polydecta* (Cramer)
14. *Mycalesis oculus* Marshall
15. *Mycalesis (Patnia Moore) junonia* Butler
16. *Mycalesis (perseus) tabitha* Fabricius
17. *Mycalesis subdita* Moore
18. *Mycalesis visala* Moore
19. *Orsotriaena (medus) mandata* Moore
20. *Ypthima (asterope) mahretta* Moore
21. *Ypthima (avanta) striata* Hampson
22. *Ypthima (baldus) madrasa* Evans
23. *Ypthima ceylonica* Hewitson
24. *Ypthima chenui* Guerin-Meneville
25. *Ypthima huebneri* Kirby
26. *Ypthima (philomela) tabella* Marshall & de Niceville
27. *Ypthima ypthimoides* (Moore)
28. *Zipaetis saitis* Hewitson
29. *Parantirrhoea marshelli* Wood-Mason

Identity, ecology and status of satyrine butterflies collected in this study with notes on the morphology of their external genitalia:

A general description of satyrid butterflies collected in this study along with notes on their distribution, habits, hosts, status and genitalia morphology is presented herein.

1. *Elymnias caudata* Butler (The Tailed Palmfly) (Plate I, Fig. 1)

Butler (1871). *Proc. Zool. Soc. Lond.*, p. 520 (Canara)

Talbot (1947). *Faun. Brit. India. Butterflies*, Vol. 2: 384.

Evans (1932). *Id. Ind. Butterflies*, p. 128.

Larsen (1988). *JBNHS*, 84: 561.

Ferguson (1891). *JBNHS*, 6:437.

D'Abra (1985). *Butterflies of the Oriental Region*, Part II: 475.

Wynter-Blyth (1957). *Butterflies of the Indian Region*, Bombay Nat. Hist. Soc., p. 126.

Description: The COMMON PALMFLY measuring 65-80 mm in expanse is brightly coloured. The male is blackish brown, with a purple gloss. The upper side of the fore wing bears a bluish band and a series of bluish white spots along the margin. The upper side of the hind wing has a broad chestnut border. The female is reddish brown with the apex and margins tinged with dark brown and having white spots. Fore wing with broad white band below apex. Sexual dimorphism is very strong, the female mimicking *Danaus genutia* and *D. chrysippus*.

Genitalia morphology: Male (Plate II, Fig. 1) - Uncus long, narrow, rod-shaped and pointed at the tip, borne on a broad basal plate bearing a narrow, curved lobe on either side. Valvae of medium length and of more or less uniform width throughout; bearing an elongate, narrow lobe on the inner margin, slightly projecting beyond the apex which is broad, fringed with short, stiff hairs. Saccus pronounced, V-shaped, vinculum with elongate, narrow arms. Arms of tegumen short. Transtilla broad with a median curve. Phallus long, narrow with a slight constriction, apex flat. Ductus ejaculatorius enters the phallus sub-basally.

Habits: These are the commonest and the most widely distributed palm butterflies usually found in cane and palm plantations. Ferguson (1891) states that it is common up to 3000 ft. They are shade-loving butterflies. Their flight is weak and the male may be often seen sitting for long periods on palm trees with the wings closed.

Hosts: Larvae develop on canes and palms. *Cocos nucifera*, *Areca catechu*, *A. triandra*, *Arenga wightii*, *Calamus rotang*, *Phoenix* sp. and ornamental palms are some of the recorded host plants (Sevastopulo, 1973: Gaonakar, un publ.).

Distribution: The range covers Peninsular India and Sri Lanka. It is rather scarce in the Nilgiris and it has been collected from Travancore to Mysore covering the Nadgani Ghat, Silent Valley, Sholayar and Nelliampathy.

Plate I (Figs. 1- 14): Some Satyrine butterflies recorded from Kerala



1. *Elymnias caudata*



2. *Lethe (drypetis) todara*



3. *Lethe (rohria) neelgheriensis*



4. *Melantis leda* Upper side



4b. *Melantis leda* Underside



5. *Melantis (phedima) varaha*



6. *Mycalesis adolphei*



7. *Mycalesis anaxias*



8. *Mycalesis igilia*



9. *Mycalesis oculus*



10. *Mycalesis (Patnia) junonia*



11. *Mycalesis (perseus) tabitha*



12. *Mycalesis subdita*



13. *Ypthima (baldus) madrasa*



14. *Zipaetis saitis*

Plate II (Figs. 1-4): Male external genitalia of Satyrine butterflies collected in this study

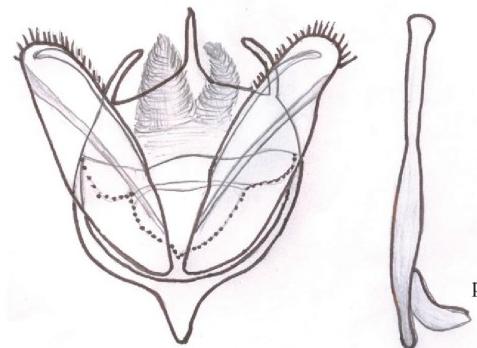


Fig. 1. *Elymnias caudata* (ventral view),
p. Phallus.

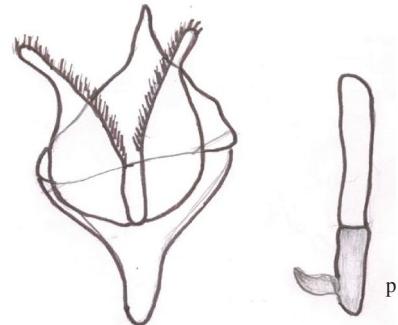


Fig. 2. *Lethe (drypetis) todara* (ventral view),
p. Phallus

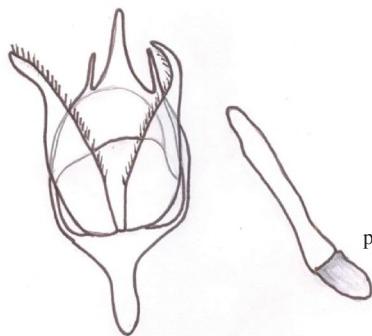


Fig. 3. *Lethe (rohria) neelgheriensis* (ventral
view), p. Phallus

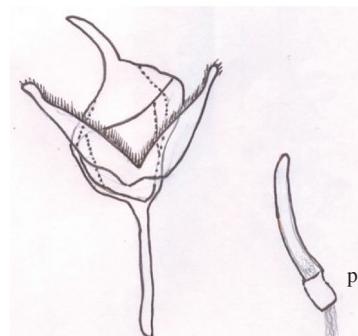


Fig. 4. *Melantis leda* (ventral view), p. Phallus.

Status: Common, wide spread (Gaonkar, 1996).

2. *Lethe europa* (Fabricius) (The Bamboo Treebrown)

Papilio europa, Fabricius (1775). *Syst. Ento.* (5) 1: 500.

Talbot (1947). *Faun. Brit. India. Butterflies*, Vol. 2: 197.

Evans (1932). *Id. Ind. Butterflies*, p. 105.

Larsen (1988). *JBNHS*, 84: 561.

D'Abra (1985). *Butterflies of the Oriental Region*, Part II: 416.

Wynter-Blyth (1957). *Butterflies of the Indian Region*, Bombay Nat. Hist. Soc., p. 92.

Collection data: Palappilly, 3 Nov. 2009.

Description: The BAMBOO TREEBROWN measuring 65-75 mm in expanse is brown above. Hind wing caudate at vein 4. Ocelli on the under side of hind wing more or less disintegrated and no markings inside basal line (line that runs from the costa through mid cell towards dorsum). Fore wing fringe chequered. Female always with a continuous white band on the upper side of fore wing. Under side of hind wing with no discal band. Male without brands.

Habits: Visits damp areas, rotting fruits and fresh cowpats. Can be trapped using bait traps with rotting crabs.

Hosts: Bamboos - *Arundinaria falcata*, *Bambusa arundinica*, *Dendrocalamus strictus*, Grasses (Sebastopulo, 1973; Gaonkar, *un publ. m.s.*).

Distribution: Southern India (Kerala, Tamil Nadu, Karnataka, Goa, Gujarat, Maharashtra (Gaonkar, 1996), Madhya Pradesh, Assam and Myanmar.

Status: Common, wide spread (Gaonkar, 1996).

3. *Lethe (drypetis) todara* Moore (The Tamil Treebrown) (Plate I, Fig. 2)

Moore (1881). *Trans. Ent. Soc. Lond.* (3): 305.

Talbot (1947). *Faun. Brit. India. Butterflies*, Vol. 2: 203.

Evans (1932). *Id. Ind. Butterflies*, p. 105.

Larsen (1988). *JBNHS*, 84: 561.

Ferguson (1891). *JBNHS*, 6:436.

D'Abra (1985). *Butterflies of the Oriental Region*, Part II: 418.

Wynter-Blyth (1957). *Butterflies of the Indian Region*, Bombay Nat. Hist. Soc., p. 93.

Collection data: Wayanad, 5 May, 2010.

Description: The TAMIL TREEBROWN measures 65 – 70 mm in expanse. Under side of hind wing with discal band and with ocelli in 3, 4 and sometimes 5, all of which are equal in size. The male is dark brown. The hind wing bears a post-discal series of three or four black ocellar spots. The female is similar to the male but paler, with a broad, oblique white discal bar and two white pre-apical spots on the upper side of the fore wing. The markings on the underside are relatively more sharply defined than in the male.

Genitalia morphology: Male (Plate II, Fig.2) - Uncus short, conical with a bluntly pointed apex. Tegumen and vinculum with narrow arms of uniform width. Valvae short, with the apical 1/3rd portion constricted and appearing as a blunt lobe. Basal part of valva swollen. A fringe of short hairs present on the inner margin of the valva extending from about 1/3rd distance from base to the apex. Saccus elongate, stout and blunt at the tip. Phallus short, of uniform length

throughout and with the basal 1/3rd portion appearing as the handle of a dagger. Apex broad. Ductus ejaculatorius enters the phallus sub-basally.

Habits: It is generally found in forests having bamboo breaks on which their larvae develop. As a result, they are found both in the plains as well as in forests to altitudes above 7000 feet in the Western Ghats. The flight is very erratic. They are attracted to toddy, sugar or sappy exudations of trees and are also reported to frequent animal (leopard) droppings.

Hosts: Its larvae feed mostly on bamboos (*Bambusa arundinacea*) (Sebastopulo, 1973) but they also seem to feed on grasses. The eggs are laid singly on the underside of leaves.

Distribution: Sri Lanka, South India to Pachmarhi, Kashmir to Assam and Burma. It has been reported from Kotagiri in the Nilgiris, the moist-deciduous forests in Biligiriranga and Wynad, the Nadgani Ghat and Silent Valley. Gaonkar (1996) reports it from Kerala, Tamil Nadu, Karnataka, Goa, Gujarat and Maharashtra.

Status: The species is endemic to Sri Lanka and South India. Common, widespread (Gaonkar, 1996).

4. *Lethe rohria neelgheriensis* (Guerin-Meneville) (The Indian Treebrown) (Plate I, Fig. 3)

Guerin-Meneville (1893). In, *Ind. Deles., Souv. Von. Ins.*, 2: 74.

Talbot (1947). *Faun. Brit. India. Butterflies*, Vol. 2: 201.

Evans (1932). *Id. Ind. Butterflies*, p. 108 (as *nilgiriensis*).

Larsen (1988). *JBNHS*, 84: 562.

Ferguson (1891). *JBNHS*, 6: 436 (as *neelgheriensis*).

D' Abrera (1985). *Butterflies of the Oriental Region*, Part II: 418.

Wynter-Blyth (1957). *Butterflies of the Indian Region*, Bombay Nat. Hist. Soc., p. 93.

Collection data: Thattakkad, 5 Nov. 2009.

Description: The COMMON TREEBROWN measures 58-70 mm in expanse. The male is dark brown. The upper side of the fore wing has apical and costal white spots. In the hind wing, the ocelli of the under side are seen as black spots. The under side of the fore wing has a broad and a narrow discal bands arranged in the form of a V. On the under side of the hind wing with a basal white line and with ocelli in 3, 4 and some times 5, all elongated and distorted; the apical ocellus is much larger. The antennae and the head, thorax and abdomen are brown.

Genitalia morphology: Male (Plate II, Fig. 3)- Uncus with a pointed stout, pointed process. Tegumen and vinculum with narrow, elongated arms. Saccus stout, basally broad, blunt at the

Plate III (Figs. 1-4): Male external genitalia of Satyrine butterflies collected in this study

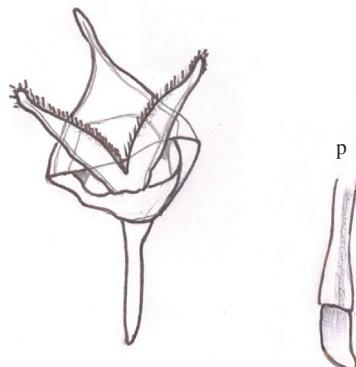


Fig. 1. *Melantis (phedima) varaha* (ventral view), p. Phallus

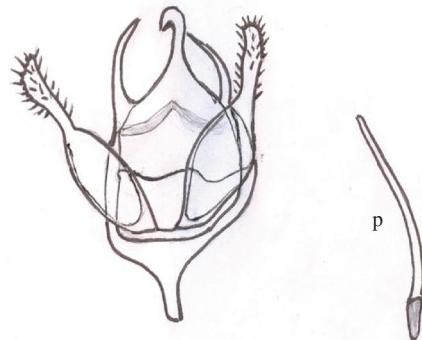


Fig. 2. *Mycalesis adolphei* (ventral view), p. Phallus

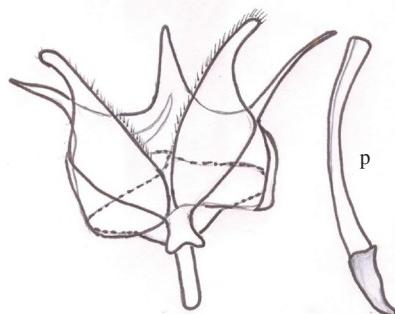


Fig. 3. *Mycalesis anaxias* (ventral view), p. Phallus

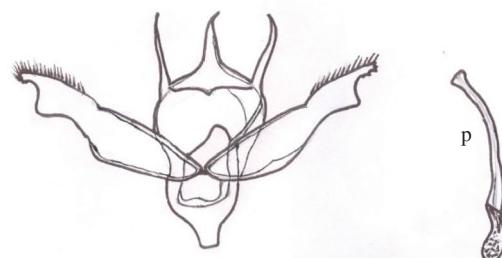


Fig. 4. *Mycalesis igilia* (ventral view), p. Phallus

proximal end and appearing as the handle of a dagger. Valvae short, apical half narrowed, ending is a blunt lobe-like portion. Phallus short, slightly narrowed in the middle, with a slight sub-apical notch.

Habits: It is an inhabitant of subtropical, evergreen and moist-deciduous forest.

Distribution: The distribution of this species extends from Sri Lanka and south India to Kashmir to Kumoan, Sikkim, Assam and Myanmar. It has been reported from the Nilgiris, Malabar and Silent Valley. Gaonkar (1996) reports it from Kerala, Tamil Nadu, Karnataka, Goa, Gujarat and Maharashtra.

Hosts: Feeds on grasses (Sebastopulo, 1973).

Status: Common, wide spread (Gaonkar, 1996).

5. *Melanitis leda* Linnaeus (The Familiar Evening Brown) (Plate I, Figs. 4a, b)

- Linnaeus (1758). *Syst. Nat.* **1** (2): 773.
 Talbot (1947). *Fauna of British India, Butterflies*, **2**: 366.
 Larsen (1988). *JBNHS*, **84**: 560.
 Ferguson (1891). *JBNHS*, **6**: 437.
 D' Abrera (1985). *Butterflies of the Oriental Region*, Part II: 410.
 Wynter-Blyth (1957). *Butterflies of the Indian Region*, Bombay Nat. Hist. Soc., p. 122.

Collection data: Parambikulam, 30 April, 2009; Vazhachal, 1, 5 May, 2009; Kattlapara, 14 Oct. 2009; Vazhani, 3 May, 2010.

Description: The FAMILIAR EVENING BROWN measuring 60-80 mm in expanse is dark brown in colour. Fore wing with 2 parallel ocelli having orange inner borders. Hind wing with 3 ocelli. Seasonal forms present. In the wet season form (*determinate* Butler), there is a large, black spot at vein 3 of fore wing and another smaller one on vein 4. Under side is greyish with striae and black lines. In the dry season form (*ismene* (Cramer), the colour is brownish and the black spots have a short yellow bar above them. Under side blotched or spotted with black.

Genitalia morphology: Male (Plate I, Fig. 4) - Uncus with an elongate, slender, blunt lobe, borne on an expanded basal part. Tegumen and vinculum with narrow, elongate arms. Valvae short, swollen in the basal and middle part and narrowed at the apical 1/3rd portion. There is a slight sub-apical constriction. The apex is blunt and rounded. Inner margin of valva fringed with a row of short, stiff hairs. Saccus with an exceptionally elongate lobe having a blunt tip. Phallus short, stout, slightly curved in the middle; proximal part broad and appearing like the handle of a sword. Distal end broadly blunt. Ductus ejaculatorius enters the phallus through the proximal end. Female - Bursa vesicular and appearing as a hood-shaped structure. Ductus long, narrow and of uniform width; basal portion swollen.

Habits: It is common on the hills up to an altitude of 4000 feet. It is also found near agricultural farms and in countryside. Its flight is rather weak, and it keeps close to the ground, frequenting both thick forest and open country. It comes out more in the open sunshine. The wet season form is as a rule more heavily ornamented with markings. Visits flowers of Lantana.

Hosts: Larvae develop on Graminae (Sebastopulo, 1973). It is a minor pest of paddy, sorghum, wheat, grasses, bamboos etc. Gaonkar (*un publ.*) gives *Cyrtococcum*, *Eleusine*, *Oplismenns composites*, *Oryza sativa* and *Sorghum* as host plants.

Distribution: The range of the species extends over Sri Lanka, Peninsular India, Assam, Burma, Andamans and even into the Malayan Sub-region. Reported from Kerala, Karnataka, Tamil Nadu, Goa and Maharashtra (Gaonkar, 1996). Specifically reported from the Nilgiris, Peechi, Sholayar, Silent Valley, Nelliampathy, Nilambur and Parambikulam.

Plate IV (Figs. 1-4): Male external genitalia of Satyrine butterflies collected in this study

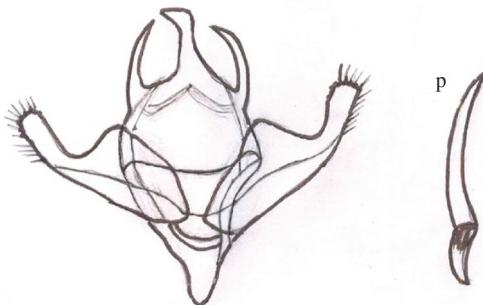


Fig. 1. *Mycalesis oculus* (ventral view), p. Phallus

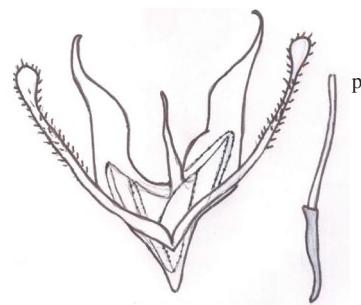


Fig. 2. *Mycalesis (patnia) junonia* (ventral view), p. Phallus

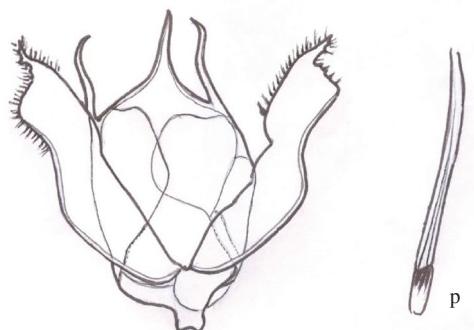


Fig. 3. *Mycalesis (perseus) tabitha* (ventral view), p. Phallus

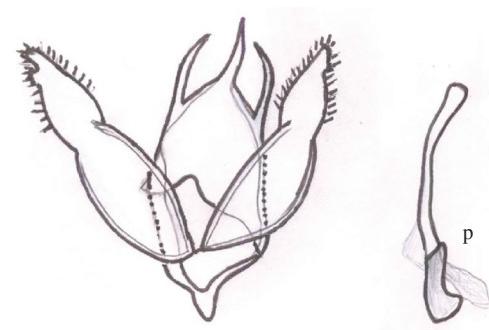


Fig. 4. *Mycalesis subdia* (ventral view), p. Phallus

Status: Common, wide spread in Kerala (Gaonkar, 1996).

6. *Melanitis (phedima) varaha* Moore (The Dark Evening Brown) (Plate 1, Fig. 5)

Moore, In, Horsfield & Moore (1857) *Cat. Lep. Ins. E.I. Co.* **1**: 224 (Canara)

Talbot (1947). *Faun. Brit. India. Butterflies*, Vol. **2**: 370.

Evans (1932). *Id. Ind. Butterflies*, p. 126.

Larsen (1988). *JBNHS*, **84**: 561.

Ferguson (1891). *JBNHS*, **6**:437 (as *bela* Moore)

D'Abra (1985). *Butterflies of the Oriental Region*, Part II: 412.

Wynter-Blyth (1957). *Butterflies of the Indian Region*, Bombay Nat. Hist. Soc., p. 123.

Collection data: Parambikulam, 1 May, 2009; Vazhachal, 5, May, 2009; Rockwood, 15 Oct. 2009; Kattlapara, 14 Oct. 2009; Thattakkad, 22 Nov. 2009; Chimmony, 3 Nov. 2009.

Description: The DARK EVENING BROWN measuring 60-85 mm in expanse is blackish brown in colour and without prominent marks. Seasonal forms present. In the wet season form, the upper side is blackish brown without markings. The termen of the fore wing is straight and not produced. The black sub-apical markings are either reduced or absent. The hind wing is uniformly dark brown, without ocelli, and its margin bears a prominent tooth-like projection at vein 3 and streaked with pale purplish lines.

The dry season form is distinguished from the wet season form by the upper side of the fore wing being pale purplish towards the terminal margins. The general ground colour is dark above. On the under side, the general ground colour is darker and the ocelli are reduced to pale spots.

Genitalia morphology: Male (Plate III, Fig. 1) - Uncus narrow, slightly narrowed basally and sub-basally swollen, apex blunt. Arms of tegumen and vinculum narrow. Valvae short, spindle-shaped, sub-epically narrowed with a blunt apex, fringed with short, stiff hairs on the inner margin. Saccus elongate, stout and bluntly pointed at the tip. Phallus short, stout, basal 1/3rd portion demarcated and appearing like the handle of a knife; apical half narrow, apex flat.

Habits: It is confined to dense, evergreen forests and is rarely found in low forests. This species resembles the preceding one closely in its habits, except that its flight is weaker and it keeps more to the jungles. This species is readily distinguished from the preceding one by the ground colour of its upper side which is much darker.

Hosts: Graminae (Sebastopulo, 1973: 165). Gaonkar (*un publ.*) gives *Andropogon*, *Apinda*, *Bambusa arundinacea*, *Cymbopogon*, *Oryza sativa*, *Panicum*, *Pennisetum*, *Seteria*, *Sorghum* (all Poaceae)

Distribution: The distribution covers Sri Lanka, Myanmar, Peninsular India (Kerala, Tamil Nadu, Karnataka, Goa, Maharastra, Gaonkar, 1996), the Himalayas, Kashmir to Sikkim, Assam and Naga Hills. It has been recorded from Kallar, Mukkali and the Nadgani Ghat.

Status: Common, wide spread (Gaonkar, 1996).

7. *Melanitis zitenius gokala* Moore (The Great Evening Brown)

Moore, *In*, Horsfield & Moore (1857). *Cat. Lep. Ins. E.I. Co.* **1**: 224 (Canara)

Talbot (1947). *Faun. Brit. India. Butterflies*, Vol.2: 375.

Evans (1932). *Id. Ind Butterflies*, p. 126.

D'Abra (1985). *Butterflies of the Oriental Region*, Part II: 410.

Wynter-Blyth (1957). *Butterflies of the Indian Region*, Bombay Nat. Hist. Soc., p. 124.

Larsen (1988). *JBNHS*, **84**: 560

Ferguson (1891). *JBNHS*, **6**: 437.

Collection data: Parambikulam, 30 April, 2009; Nelliampathy, 13 May, 2009.

Description: The GREAT EVENING BROWN measuring 75-85 mm in expanse has a general resemblance to the Common Evening Brown, but larger. The costa of the fore wing is more rounded, and the apical markings on the upper side of the fore wing are generally more luxuriant than in *M. leda*. The dry season form is pale brown below with a few black patches. Fore wing more prominently angled. In the wet season forms, the dark discal line is prominent and the ground colour is reddish brown. Seasonal forms present.

Habits: Found only in deep jungles up to 4000 ft., usually hiding under bushes.

Hosts: Graminae: Bamboos. *Bambusa arundinacea*, Ochlandra (Sebastopulo, 1973:165; Gaonkar (*un publ.* notes)

Distribution: The distribution covers South India and from Kumaon to Indo China. It is mostly confined to dense forests up to 4000 feet elevation. It has been recorded from the Coonoor Ghat, Kallar and the Nadgani Ghat.

Status: Common, wide spread in Kerala (Gaonkar, 1996).

8. *Mycalesis adolphi* Guerin-Meneville (The Red Eye Bushbrown) (Plate I, Fig. 6)

Guerin-Meneville (1843). *In, Deless. Sour. Voy. Ind.* **II**: 76.).

Talbot (1947). *Faun. Brit. India. Butterflies*, Vol. **2**: 147.

Larsen (1988). *JBNHS*, **84**: 564.

Evans (1932). *Id. Ind. Butterflies*, p. 100.

D'Abra (1985). *Butterflies of the Oriental Region*, Part II: 457.

Wynter-Blyth (1957). *Butterflies of the Indian Region*, Bombay Nat. Hist. Soc., p. 88.

Collection data: Chembra, May, 2010.

Description: The RED EYE BUSHBROWN measuring about 60 mm in expanse is chocolate brown above, with small ocelli from 2 to 4 on hind wing and in 2 and 5 in fore wing and with a reddish brown ring in 5. Male with no brand on under side of fore wing.

Genitalia morphology: Male (Plate III, Fig. 2) - Uncus conical, distal end curved, pointed hook-shaped. Tegumen and vinculum with narrow arms. Arm of tegumen elongated, pointed at the

tip and distally. Saccus short, stout and blunt resembling the handle of a knife. Valvae short, narrow, basal 2/3rd swollen and the apical part narrow, apically broad, bearing short hairs. Phallus long, very slender, curved in the middle, apex blunt and basal part resembling the handle of a sword.

Habits: Generally found along dense forest tracts between 4000 to 7000 ft. Flies at the edges of sholas. Recorded from May to December.

Distribution: Southern India: Coorg, the Nilgiris. North of Palghat gap in Kerala, Tamil Nadu and Karnataka.

Hosts: Grasses (Gaonkar, *in prep.*).

Status: Common in sholas in the Nilgiris above 1900 ft. (Larsen, 1988). Restricted (Gaonkar, 1996)

9. *Mycalesis anaxias* Hewitson (The White bar Bushbrown) (Plate I, Fig. 7)

Hewitson (1862). *Exot. Butt.* **3:** 86

Talbot (1947). *Faun. Brit. India. Butterflies*, Vol. **2:** 119.

Evans (1932). *Id. Ind. Butterflies*, p. 97.

Larsen (1988). *JBNHS*, **84:** 562.

Ferguson (1891). *JBNHS*, **6:**436 (as *M. (virapa) anaxias*).

D'Abra (1985). *Butterflies of the Oriental Region*, Part II: 452.

Wynter-Blyth (1957). *Butterflies of the Indian Region*, Bombay Nat. Hist. Soc., p. 83.

Collection data: Pandimatta, 14 Oct.2009, Thattakkad,; 5 Nov.2009.

Description: The WHITE BAR BUSHBROWN Measures 48-55 mm in expanse. It is dark brown in colour with a sub-apical white bar on the Fore wing. No ocelli. Male with a black brand each on the upper side of fore and hind wings.

Genitalia morphology: (Plate III, Fig. 3) Male - Uncus conical with a long, pointed lobe. Tegumen and vinculum short with narrow arms. An elongate, slender, apically pointed, curved lobe on either side of the base of uncus. Saccus short w-shaped, with a notch in the middle. Valvae short, more or less of uniform width throughout, the apical portion narrow with a sub-basal hump, the distal end of valvae drawn out into a narrow, pointed lobe; fringes of short, stiff hairs present apically. Outer margin of valvae uneven and curved. Phallus long and slender slightly curved, of uniform width; distal end narrow and blunt, proximal part distinctly resembling the handle of a dagger.

Habits: It is a hill species confined to the wet evergreen forests up to 6000 feet elevation. Flies low, close to the ground.

Distribution: Distribution covers hills of south India (Kerala, Tamil Nadu, Karnataka, Goa, Maharashtra, Gujarat) Sikkim to Assam and Myanmar. It has been recorded from Coorg, Coonoor, the Nadgani Ghat, and Silent Valley (Mathew, 1999).

Hosts: Poaceae (Gaonkar, *un publ.*).

Status: Common, wide spread (Gaonkar, 1996).

10. *Mycalesis igilia* Fruhstorfer (The Small Long-brand Bushbrown) (Plate I, Fig. 8)

Fruhstorfer (1911). In, Seitz, *Macrolep. of the World*, 9: 346.

Larsen (1988). *JBNHS*, 84: 563.

D'Abra (1985). *Butterflies of the Oriental Region*, Part II: 457.

Collection data: Chembra, May, 2010.

Description: The SMALL LONG-BRAND BUSHBROWN measuring 40-48 mm in expanse is brownish in colour and it can be easily identified by its very long brand on the Fore wing which extends beyond the white discal line which is often angled towards the tornus at vein 1b. Seasonal forms present.

Genitalia morphology: Male (Plate III, Fig. 4)- Uncus narrow, long with a sharply pointed apex which is slightly bent to one side; basal part broad bearing an elongate, apically curved and pointed lobe on either side. Saccus short, U-shaped, with a flat tip. Valvae elongate, narrow, basal 2/3rd portion lanceolate and with a constriction; apical part deeply notched and humped sub-apically; with an apical blunt lobe-like tip. A fringe of short, stiff hairs present for nearly 1/3rd length from apex along the inner margin. Phallus long, narrow, slightly curved, distal end swollen, basal portion appearing as the handle of a sword.

Habits: It is commonly found in dense moist deciduous forests, usually in bamboo area up to 3000 feet elevation. Commonly found in the Nilgiri Biosphere Reserve at about 3000 feet during the months September to October. Restricted to humid, evergreen forests (Gaonkar, 1996).

Distribution: Recorded from Coorg, the Nilgiris, Wynad and Silent Valley.

Hosts: Grasses (*Lophopogon tridengtatus*, *Leersia* spp., *Oryza sativa*) (Gaonkar, *in prep.*).

Status: It is endemic to Southern India. Rare, restricted (Gaonkar, 1996).

11. *Mycalesis (khasia) orcha* Evans (The Pale-brand Bushbrown)

Evans (1912). *JBNHS*, **21**: 596.

Talbot (1947). *Faun. Brit. India. Butterflies* Vol. **2**: 143 (as *M. visala orcha* Evans).

Larsen (1988). *JBNHS*, **84**: 563.

Wynter-Blyth (1957). *Butterflies of the Indian Region*, Bombay Nat. Hist. Soc., p. 87.

Description: The PALE-BRAND BUSHBROWN measuring 42-55 mm in expanse is brownish with a white and broad discal band. Seasonal forms present. Ground color pale in wet season forms. Brand on the upper side of hind wing yellowish brown. The brand does not go beyond the white discal line.

Habits: It is found in dense, moist deciduous or evergreen forests.

Distribution: The range covers Southern India and Assam up to Myanmar. It has been reported from Palnis, Shevaroys, Coorg, the Nilgiris and Wayanad.

Hosts: Grasses (Gaonkar, *in prep.*).

Status: Common, but restricted (Gaonkar, 1996)

12. *Mycalesis (mineus) polydecta* (Cramer) (The Dark-brand Bushbrown)

Papilio polydecta Cramer, 1777, *Pap. Op.ct.* **2**: 46.

Talbot (1947). *Faun. Brit. India. Butterflies*, Vol. **2**: 136.

Evans (1932). *Id. Ind. Butterflies*, p. 98.

Larsen (1988). *JBNHS*, **84**: 563.

Ferguson (1891). *JBNHS*, **6**: 936 (as *M. (Celystrina) mineus* Linnaeus form *justina*).

D'Abrera (1985). *Butterflies of the Oriental Region*, Part II: 458.

Wynter-Blyth (1957). *Butterflies of the Indian Region*, Bombay Nat. Hist. Soc., p. 85.

Collection data: Vazhachal, 1 May, 2010.

Description: The DARK-BRAND BUSHBROWN measures 40-50 mm in expanse. Brown in colour with the ocellus on the upper side of fore wing situated in a more or less pale area. Under side with a sub marginal white line across the wing, a series of ocelli and a broad white band.

Hosts: Grasses (Sebastopulo, 1973). *Lophopogon tridentatus*, *Leersia hexandra*, *Oryza sativa* (Gaonkar, *un publ.*)

Distribution: It is found on the hills and plains at low elevations. The range covers Sri Lanka, most of India- Kerala, Tamil Nadu, Karnataka, Goa, Maharashtra and Gujarat (Gaonkar, 1996) - the Philippines, Taiwan and Malaysia. Recorded from Nadgani and Mukkali.

Status: Common, wide spread (Gaonkar, 1996).

13. *Mycalesis oculus* Marshall (The Red- disc Bushbrown) (Plate I, Fig. 9)

Marshall (1880). *J. asiat. Soc. Beng.* **49** (2): 247.

Talbot (1947). *Faun. Brit. India, Butterflies*, Vol. 2: 148.

Ferguson (1891). *JBNHS*, **6**: 436.

Wynter-Blyth (1957). *Butterflies of the Indian Region*, Bombay nat. Hist. Soc., p. 84.

Description: It is rich brown above. There are prominent ocellus in 2 on upper side of fore wing placed on broad and deep yellow area. Small ocellus in 5 and small ocelli in 2 to 4 on upper side of hind wing. In males, black colour brand seen in under side of fore wing and black brand with brown tuft in the upper side of hind wing.

Genitalia morphology: Male (Plate IV, Fig. 1) - Uncus short, stout, apically with a conical part resembling the head of a bird, with a pointed tip. An elongate, slender, pointed process present basally on either side. Arms of tegumen and vinculum narrow. Valvae swollen in the basal part with a sharp constriction at about 1/3rd length from the apex producing a stout apically flat lobe fringed with short, stiff hairs. Phallus long, slender, slightly curved pointed at the apex. Basal portion of phallus, curved, stout and pointed proximally.

Habits: It is high elevation *Mycalesis* in hills to south Nilgiris. Generally found in jungle country above 3,000 feet.

Distribution: Hills of Southern India. (South of Nilgiris)

Hosts: *Bambusa* sp. (Gaonkar *in prep.*).

Status: Endemic, common, restricted (Gaonkar, 1996).

14. *Mycalesis (patnia* Moore)*junonia* Butler (The Glad - eye Bushbrown) (Plate I, Fig. 10)

Butler (1868). *Cat. Satyridae Brit. Mus.*, p.146.

Talbot (1947). *Faun. Brit. India. Butterflies*, Vol.2: 164.

Evans (1932). *Id. Ind. Butterflies* p. 102.

Larsen (1988). *JBNHS*, **84**: 562.

Ferguson (1891). *JBNHS*, **6**: 436.

D'Abra (1985). Butterflies of the Oriental Region, Part II: 457.

Wynter-Blyth (1957). Butterflies of the Indian Region, Bombay Nat. Hist. Soc., p. 91.

Collection data: Vazhachal, 5 & 6 May, 2009; Pandimatta, 14 Oct. 2009; Rockwood, 15 Oct. 2009; Thattakkad, 15 Nov. 2009.

Description: The GLAD-EYE BUSHBROWN measuring 40-45 mm in expanse is characterized by the pupilled ocellus in 2 on the upper side of fore wing which is set on the lower and outer edge of a circular white or yellow patch. Wings are rounded and the underside variegated.

Genitalia morphology: Male (Plate IV, Fig.2) - Uncus long, slender, slightly curved, apically narrow and bluntly pointed at the tip. Tegumen and vinculum with narrow, slender arms. Saccus 'V'- shaped with a blunt apex. Valvae with an outer elongate, narrow lobe with an apically round lobe and fringed with short, stiff hairs on the distal $\frac{1}{2}$ portion; an inner, basally swollen lobe having a narrowed, wavy, curved apical half ending in a pointed apex. Phallus long, narrow with the basal $\frac{1}{3}$ rd part stout with wavy margins and appearing as a tool handle; the remaining part of uniform width, slightly curved and with the apex blunt.

Habits: Tropical and subtropical evergreen forests and bamboo jungle. Rarely found in disturbed forests. Observed in large numbers on fruits of Figs lying on the forest floor. Attracted to toddy or sugar (Larsen, 1988).

Distribution: Southern India (Kerala, Tamil Nadu, Karnataka (Gaonkar, 1996) and Sri Lanka. Recorded from Kotagiri and upto 6000 ft. in the Nilgiris.

Hosts: Grasses. *Oryza* (Sebastopol, 1973). It can sometimes form a pest of the cultivated rice (Gaonkar, *in prep.*).

Status: Endemic to Southern India and Sri Lanka. Common, restricted (Gaonkar, 1996).

15. *Mycalesis (perseus) tabitha* (Fabricius) (The Indian Bushbrown) (Plate 1, Fig. 11)

Papilio tabitha Fabricius (1793). *Ent. Syst. (3) 1:* 743.

Talbot (1947). *Faun. Brit. India. Butterflies*, Vol. 2: 131.

Larsen (1988). *JBNHS*, 84: 562.

Ferguson (1891). *JBNHS*, 6: 436.

D'Abra (1985). *Butterflies of the Oriental Region*, Part II: 458.

Wynter-Blyth (1957). *Butterflies of the Indian Region*, Bombay Nat. Hist. Soc., p. 85.

Collection data: Vazhachal; 5, 6 May, 2009; Pandimatta, 14 Oct. 2009; Palappilly, 3 Nov. 2009; Chimmony, 3 Nov. 2009; Thattakkad, 5 Nov. 2009; Vazhani, 3 May, 2010.

Description: The INDIAN BUSHBROWN measuring 38-55 mm in expanse is brownish in colour. Upper side of fore wing with an ocellus which is not ringed. The male can usually be recognised by the brand on the under side fore wing tornus which is very small and black. On the hind wing under side the eye-spot in space 3 is usually out of line with the others forming eye-spots, a condition slightly approached in some other species. Seasonal forms present.

Genitalia morphology: Male (Plate IV, Fig. 3) - Uncus conical, dorsally broad, distal end long, narrow, slightly curved and sharply pointed at the tip. Tegumen and vinculum with narrow arms. Arms of tegumen elongate, extended distally, sinuous and sharply pointed at the tip. Phallus of medium length, slender, curved in the middle with a linear sclerotized patch in the center.

Habits: It is found in wet, dense forests. Usually keeps to low elevations although it may ascend to 3000 or 4000 feet elevation. Usually found in shady places. It is a weak flier. Can be attracted to sugar and rotting fruit. Rarely found to visit flowers. The males are occasionally found on damp places.

Hosts: Grasses (Sebastopulo, 1973). *Imperata cylindrica* (Gaonkar in press); *Oryza*, *Oplismenus composites* (Poaceae).

Distribution: The species is found in Sri Lanka and most of India- Kerala, Tamil Nadu, Karnataka, Goa, Maharashtra and Gujarat (Gaonkar, 1996) - and Malaysia. It has been recorded from the Nilgiris, Nadgani and Silent Valley (Larsen, 1988).

Status: Common, wide spread (Gaonkar, 1996).

16. *Mycalesis subdita* Moore (The Tamil Bushbrown) (Plate 1, Fig. 12)

Moore (1891). *Lep. Ind.* **1**: 194.

Talbot (1947). *Faun. Brit. India. Butterflies*, Vol.2: 143.

Evans (1932). *Id. Ind. Butterflies*, p. 99.

Larsen (1988). *JBNHS*, **84**: 563.

D' Abrera (1985). *Butterflies of the Oriental Region*, Part II: 457.

Wynter-Blyth (1957). *Butterflies of the Indian Region*, Bombay nat. Hist. Soc., p. 86.

Collection data: Parambikulam, 1 & 2 May, 2009, Palappilly, 3 Nov. 2009; Vazhani, 3 May, 2010.

Description: The TAMIL BUSHBROWN measuring 45-55 mm in expanse is dark brown above with a prominent eye spot with narrow well defined ring in 2 on the upper side of the wing and with a prominent pale marginal line followed by two black lines. Seasonal forms present. The wet season form is very dark below which has an ocellus in 1 on under side of hind wing.

Genitalia morphology: Male (Plate IV, Fig.4) - Uncus long, narrow and apically pointed. A long, narrow, apically pointed lobe present basally, on either side of the uncus. Arms of tegument and vinculum narrow. Valvae ovate with a constriction in the middle. Apical portion of valva bearing a fringe of short, stiff hairs and with a sub basal notch, leading to the formation of a distinct apical lobe. Saccus short V-shaped. Phallus short, narrow, curved in the middle. Proximal part of phallus stout, curved on one side and appearing as the handle of a knife. Apex of phallus distinctly broad.

Habits: Common in low elevations in hills to about 3000 ft.

Distribution: Sri Lanka and Southern India (Kerala, Tamil Nadu, Karnataka, Goa, Maharashtra and Gujarat). Recorded from the eastern slopes of the W. Ghats (Gaonkar, 1996). the Nilgiris, Common in Kallar of the Nilgiris.

Status: Rare, restricted (Gaonkar, 1996).

17. *Mycalsesis visala* Moore (The Long- brand Bushbrown)

Moore, In, Horsfield & Moore (1857). *Cat. Lep. Ins. Mus. East Ind. Coy.* **1**: 230.

Talbot (1947). *Faun. Brit. India, Butterflies*, Vol. **2**: 140.

Evans (1932). *Id. Ind. Butterflies*, p. 98.

Larsen (1988). *JBNHS*, **84**: 563.

Ferguson (1891). *JBNHS*, **6**: 936 (as form of *M. (Celysima) perseus* Fabricius).

D' Abrera (1985). *Butterflies of the Oriental Region*, Part II: 457.

Wynter-Blyth (1957). *Butterflies of the Indian Region*, Bombay nat. Hist. Soc., p. 6.

Collection data: Nelliampathy, 12 & 13 May 2009, Vazhachal, 6 May, 2009.

Description: The LONG-BRAND BUSHBROWN measuring 45-55 mm in expanse is dark brown above with a prominent eye in 2 on the upper wing. Seasonal forms present. Fore wing sharp, pointed in Dry Season Form and rounded in Wet Season Form.

Habits: Scarce in north-west of its range, fairly abundant elsewhere at low elevations.

Distribution: Southern Kerala, Tamil Nadu, Karnataka (Gaonkar, 1996) and Central India, Sikkim, Assam, Myanmar, Thailand, Indo China. In low land forest and occasionally above 1800 ft. (Gaonkar, *in prep.*)

Hosts: Grasses (Sevastopulo, 1973).

Status: Common, but restricted (Gaonkar, 1996).

18. *Orostrionea (medus) mandata* Moore (The Nigger or Medus Brown)

Mycalesis mandata Moore, 1857. In, Horsfield & Moore (1857) *Cat. Lep. Ins. E. I. Coy.* 1: 234.

Talbot (1947). *Faun. Brit. India. Butterflies*, Vol. 2: 350.

Evans (1932). *Id. Ind. Butterflies*, p. 123.

Larsen (1988). *JBNHS*, 84: 564.

Ferguson (1891). *JBNHS*, 6: 436.

D'Abra (1985). *Butterflies of the Oriental Region*, Part II: 446.

Wynter-Blyth (1957). *Butterflies of the Indian Region*, Bombay Nat. Hist. Soc., p. 120.

Collection data: Thattakkad, 5 Nov. 2009; Vazhani, 3 May, 2010, Chembra, 6 May, 2010.

Description: The NIGGER measuring 45-55 mm in expanse is dark brownish, unmarked above except for two very narrow pale line on the termen. The discal band from below shows through faintly. Below, there is a white discal band across both wings. Underside of fore wing with very prominent ocelli in 2 and 5 and under side of hind wing in 2, 5 and a smaller one in 6.

Habits: Prefers low level wet forests. Generally seen during the monsoon season.

Distribution: Southern India (Kerala, Tamil Nadu, Karnataka (Gaonkar, 1996), Sri Lanka and up to Australia. Recorded from Kallar in the Nilgiris.

Hosts: Grasses. *Imperata* sp. and *Oryza sativa* (Sevastopulo, 1973).

Status: Monobasic genus, fairly common, but restricted (Gaonkar, 1996).

19. *Ypthima asterope mahratta* Moore (The Regular Threering)

Talbot (1947). *Faun. Brit. India. Butterflies*, Vol. 2: 525.

Evans (1932). *Id. Ind. Butterflies*, p. 100.

Larsen (1988). *JBNHS*, 84: 565.

D'Abra (1985). *Butterflies of the Oriental Region*, Part II: 464.

Wynter-Blyth (1957). *Butterflies of the Indian Region*, Bombay Nat. Hist. Soc., p. 115.

Description: The REGULAR THREERING measures 30-37 mm in expanse. Seasonal forms present. In the wet season form, the upperside is dull brown with a whitish fringe. The fore wing bears a white-centred black sub-apical ocellus. The hind wing is uniform with a single small sub-tornal ocellus. The underside is greyish white with very fine transverse striations. On the underside of the fore wing a discal and sub terminal dark brown bands are present,

meeting below the ocellus to form a loop. Three ocelli present on the underside of the hind wing- one apical and two tornal. Upperside of hind wing with an ocellus on 2 only. The antennae, head, thorax and abdomen are dull brown. In the dry season form, the ground colour is paler and the ocelli on the underside are reduced to minute specks or absent altogether.

Habits: It is generally found in the plains and rarely found at higher elevations. Abundant all the year round in the plains and in forest where it is generally found among bushes flying at low levels.

Distribution: The distribution covers the whole of India and Baluchistan and Myanmar. Kerala, Karnataka, Tamil Nadu and Goa (Gaonkar, 1996). It has been reported from the Nilgiris and the Nadgani Ghat (Larsen, 1988).

Hosts: Grasses - *Cynodon dactylus*, *C. plectostachyus* (Gaonkar, *in prep.*).

Status: Common, widespread (Gaonkar, 1996).

20. *Ypthima avanta* Moore (The Jewel Fourring)

Moore (1874). *Proc. Zool. Soc. Lond.*, p. 567.

Talbot (1947). *Faun. Brit. India, Butterflies*, Vol. 2: 332.

Evans (1972). *Id. Ind. Butterflies*, p. 121.

Larsen (1988). *JBNHS*, 84: 565.

D'Abra (1985). *Butterflies of the Oriental Region*, Part II: 466.

Wynter-Blyth (1957). *Butterflies of the Indian Region*, Bombay nat. Hist. Soc., p. 118.

Description: The JEWEL FOUR RING measuring 30-45 mm in expanse has three tornal ocellus in a straight line and two apical ocellus in 5, 6.

Distribution: Peninsular India (Kerala, Karnataka, Tamil Nadu, Goa and Maharashtra (Gaonkar, 1996), Sri Lanka. Recorded at 3000 ft. elevation in the Nilgiris during August, December and January, also from Burnside Estate at 1400m.

Hosts: *Arundinella* spp., *Cynodon* spp. (Gaonkar, *un publ.*).

Status: Common, but restricted (Gaonkar, 1996).

21. *Ypthima (baldus) madrasa* Evans (The Hindustan Fivering) (Plate 1, Fig. 13)

Evans (1923). *JBNHS*, 29:787.

Evans (1972). *Id. Ind. Butterflies*, p. 122.

Larsen (1988). *JBNHS*, 84: 566.

Ferguson (1891). *JBNHS*, 6: 436.

D' Abrera (1985). *Butterflies of the Oriental Region*, Part II: 466.

Wynter-Blyth (1957). *Butterflies of the Indian Region*, Bombay Nat. Hist. Soc., p. 117.

Collection data: Vazhachal, 6 May, 2009; Pandimatta, Oct. 2009; Chimmony, 3 Nov. 2009; Rockwood, 15 Oct. 2009; Thattakkad, 5 Nov. 2009.

Description: The HINDUSTAN FIVE RING measures 32–48 mm in expanse. Seasonal forms are present. In the wet season form, the upper side is brownish, with the terminal margin of wings more dark. The fore wing bears a double-pupillated, yellow-ringed, black ocellus and two smaller, single-pupillated ocelli on the hind wing.

The underside is brownish white, with transverse brown striations. The fore wing has a large ocellus as on the upperside and the hind wing bears six smaller ocelli arranged in three pairs. There are also distinct sub-terminal, discal and sub-basal transverse brown bands on both the wings on the under side. There is a prominent sex brand.

The area surrounding the ocellus on the upper side in both wings are paler in the female. The ground colour on the under side of wings is also paler and the transverse bands are more sharply defined. The dry season form is paler. In this, the ocelli on the under side of the hind wing are reduced and appear as dots. The antennae, head, thorax and abdomen are dull brown.

Genitalia morphology: Male (Plate V, Fig. I) - Uncus basally broad, distally narrowed and pointed. Tegumen elongate with narrow arm. Vinculum short. Saccus short, U-shaped. Valvae short, apically broad and with a notch in the middle; sub-apically with a deep constriction on

Plate V (Figs. 1-2): Male external genitalia of Satyrine butterflies collected in this study

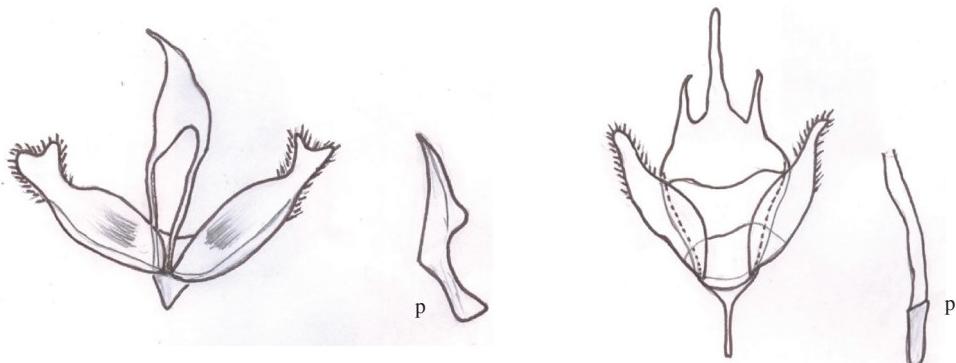


Fig. 1. *Ypthima baldus* (*madrasa*)
(ventral view), p. Phallus

Fig. 2. *Zipaetis saitis* (ventral view), p. Phallus

the inner margin; fringe of short, stiff hairs confined to the apical part. Phallus short, basal 1/3rd portion appearing as the handle of a knife and having a hump-shaped portion at about the middle; apical portion sharply pointed.

Habits: The flight is stronger. Frequent visitor to flowers and often basks in the sun with the wings three-fourths open.

Distribution: It is a very common and widely distributed species found all over India from the Himalayas to Southern India. It is extremely common in Southern India, being found in all seasons of the year both in the plains and in the hills up to an altitude of about 7000 feet. It inhabits both open country and forest regions of tropical, subtropical and mixed deciduous types. It has been collected from Silent Valley and Sholayar. Its distribution covers the whole of India and then east to Japan. It is not reported from Sri Lanka.

Hosts: Grasses - *Cynodon dactylus*, *C. plectostachyus* (Gaonkar, *un publ.*).

Status: Common, widespread (Gaonkar, 1996).

22. *Ypthima ceylonica* Hewitson (The Ceylon / White Fourring)

Hewitson (1865). *Trans. ent. Soc. Lond.*, 1864: 288.

Talbot (1947). *Faun. Brit. India, Butterflies*, Vol. 2: 328.

Larsen (1988). *JBNHS*, 84: 565.

Ferguson (1891). *JBNHS*, 6: 436.

D'Abra (1985). *Butterflies of the Oriental Region*, Part II: 464.

Wynter-Blyth (1957). *Butterflies of the Indian Region*, Bombay Nat. Hist. Soc., p. 115.

Description: The CEYLON / WHITE FOURRINGD measuring 30-35 mm in expanse has three tornal and one apical ocellus on the under side of hind wing. Upperside of hind wing with ocelli in 2 and 3 and not on a dark band unlike in *Y. chenui* in which the ocelli are on a dark band. Tornal half of upperside of hind wing white. Seasonal forms present.

Habits: Found in clearings, along roadsides and in open hill country up to 3000 ft.

Distribution: North Western India to Peninsular Malaysia, Sri. Lanka, Singapore, Thailand. Kerala, Karnataka, Tamil Nadu and Goa (Gaonkar, 1996). Reported from Palnis, Coorg, the Nilgiris, Travancore, Orissa and Bengal.

Hosts: Grasses (Sebastopulo, 1973). *Cynodon dactylus* (Gaonkar, *un publ.*).

Status: Locally common, widespread (Gaonkar, 1996).

23. *Ypthima chenui* Guerin-Meneville (The Nilgiris Fourring)

Guerin-Meneville (1843). *In, Deless. Voy. Ind.* **II**:77.

Talbot (1947). *Faun. Brit. India, Butterflies*, Vol. **2**: 326.

Evans (1972). *Id. Ind. Butterflies*, p. 121.

Larsen (1988) *JBNHS*, 84: 566.

Ferguson (1881). *JBNHS*, **6**: 436.

D'Abrera (1985). *Butterflies of the Oriental Region*, Part II: 466.

Wynter-Blyth (1957). *Butterflies of the Indian Region*, Bombay Nat. Hist. Soc., p. 115.

Collection data: Parambikulam, 1 May, 2009.

Description: The NILGIRI FOURRING measures 36-46 mm in expanse. They are brownish. Underside of hind wing whitish with prominent white and chestnut bands and three tornal and one apical ocellus. Ocellus on the upper side of hind wing prominent. Seasonal forms not present.

Habits: It inhabits the open plateaux, above 6000 ft in the Nilgiris, above 4000 ft. in Coorg and at about 800 ft. in Travancore (Larsen, 1988).

Distribution: Kerala, Karnataka, Tamil Nadu, Goa and Maharastra (Gaonkar, 1996). It is endemic to the highest mountains north of the Palghat gap. It has been reported from Coorg, the Nilgiris and the Anamalai hills. It inhabits the open plateau above 6000 feet in the Nilgiris and also at as low as 800 feet in Travancore.

Hosts: *Arundinella* spp., *Cynodon* spp. (Gaonkar, *un publ.*).

Status: Endemic to southern India (Nilgiris). Common, but restricted (Gaonkar, 1996).

24. *Ypthima huebneri* Kirby (The Hubner's Fourring)

Kirby (1891). *Syst. Cat. Diurn. Lep.*, p. 95.

Talbot (1947). *Faun. Brit. India, Butterflies*, Vol. **2**: 329.

Evans (1972). *Id. Ind. Butterflies*, p. 121.

Larsen (1988) *JBNHS*, 84: 565.

D'Abrera (1985). *Butterflies of the Oriental Region*, Part II: 464.

Wynter-Blyth (1957). *Butterflies of the Indian Region*, Bombay nat. Hist. Soc., p. 116.

Collection data: Kattlapara, 14 Oct. 2009; Rockwood, 15 Oct. 2009; Chimmony, 3 Nov. 2009; Thattakkad, Nov. 2009; Vazhachal, May, 2010; Wayanad, May, 2010.

Description: The HUBNER'S FOURRING measuring 30-40 mm in expanse has three tornal and one apical ocellus on the under side of hind wing. Upper side of hind wing with ocelli in 2 and 3 and not on a dark band unlike in *Y. chenui* in which the ocelli are on a dark band. Tornal half of upper side of hind wing not white. Seasonal forms strongly marked. Seasonal forms present.

Habits: Found both in open hill country and forest. Prefer tropical evergreen forests up to 4000-5000 ft. Generally found in bamboo areas.

Distribution: Himalayas, India (Kerala, Karnataka, Tamil Nadu, Goa and Maharastra (Gaonkar, 1996), Sri Lanka and Myanmar.

Hosts: Adults generally visit fallen fruits. Larvae feed on grasses: *Cynodon dactylon*, *C. plectostachyus* (Gaonkar, *un publ.*).

Status: Common, widespread (Gaonkar, 1996).

25. *Ypthima (Philomela) tabella* Marshall (The Baby Fivering)

Marshall (1883). *Butterflies of India, Burma and Ceylon*, 1: 221- 234.

Talbot (1947). *Faun. Brit. India, Butterflies*, Vol. 2: 335.

Evans (1972). *Id. Ind. Butterflies*, p. 121.

Larsen (1988). *JBNHS*, 84: 566.

D' Abrera (1985). *Butterflies of the Oriental Region*, Part II: 465.

Wynter-Blyth (1957). *Butterflies of the Indian Region*, Bombay Nat. Hist. Soc., p. 117.

Collection data: Chembra, 6 May, 2010.

Description: The BABY FIVERING is a small brown butterfly measuring 23-25 mm in expanse. It has a prominent double-pupillated ocellus below the apex of the fore wing. Under side of hind wing with three tornal ocelli not in line. Below, with the only marginal band which is obscure. Male with no brand.

Habits: Prefers clearings in forest and on grassy hill tops fluttering close to the ground.

Distribution: The distribution covers North Burma, Vietnam, Malaysia, Sumatra, Java, Bali and Sulawesi. It has been reported from Kerala (Wayanad), Karnataka, Tamil Nadu (The Nilgiris), Goa and Maharastra (Gaonkar, 1996).

Hosts: *Arundinella* spp., *Cynodon* spp. (Gaonkar, *un publ.*).

Status: Extremely rare (Gaonkar, 1996).

26. *Ypthima ypthimoides* (Moore)

Callerebis ypthimides Moore (1887). *Lep. Ceylon*, **1**: 307

Talbot (1947). *Faun. Brit. India, Butterflies*, Vol. **2**: 326..

Collection data: Rajamala, 30 April, 2010; Mannavan Shola, 30 April, 2010.

Distribution: Southern India (Talbot, 1947). Kerala (Travancore) and Tamil Nadu (Gaonkar, 1996).

Hosts: *Arundinella ciliata*, *A. setosa*, *Cynodon* spp. (Gaonkar, *un publ.*)

Status: Endemic, common, but restricted (Gaonkar, 1996).

27. *Zipaetis saitis* Hewitson (The Tamil Catseye) (Plate 1, Fig. 14)

Hewitson (1863). *Illustr. Exot. Butts*. **3**: 100

Talbot (1947). *Faun. Brit. India, Butterflies*, Vol. **2**: 345.

Larsen (1988). *JBNHS*, **84**: 564.

D'Abrera (1985). *Butterflies of the Oriental Region*, Part II: 472.

Wynter-Blyth (1957). *Butterflies of the Indian Region*, Bombay Nat. Hist. Soc., p. 119.

Collection data: Nelliampathy, 13 May, 2009; Kattlapara, 14 Oct. 2009; Pandimatta, 14 Oct. 2009.

Description: The TAMIL CATSEYE measures 60-65 mm in expanse. The upperside is velvety black. The fore wing bears a broad, oblique, white band from the middle of the costa to nearly the margin on the termen. The hind wing bears a similar broad, white band extending almost parallel to the posterior portion of the terminal margin. The outer margin of this band is concavely excavated between the veins.

The under side is similar, but paler. The white bands are as on the upper side. There is a sub-terminal wavy line on both the fore and hind wings on the underside. The underside of the fore wing is without ocelli, but the underside of the hind wing bears a row of five large, prominent ocelli. The head, thorax and abdomen are dark brown and the antennae reddish brown.

Genitalia morphology: Male (Plate V, Fig.2) - Uncus with elongate, slender, blunt lobe, borne on an expanded basal part bearing an elongate apically pointed lobe on either side. Tegumen and vinculum with narrow, elongate arms. Saccus basally U-shaped bearing an elongated narrow process. Phallus elongate, narrow, more or less of uniform width, slightly curved sub-apically, the proximal part appearing like the handle of a sword, slightly narrowed and blunt at the proximal end.

Habits: Its flight is weak and seldom comes out into the open. It is attracted to sugar solution and over-ripe fruits.

Distribution: Kerala, Karnataka, Tamil Nadu and Goa (Gaonkar, *in prep.*). It is found along the slopes of the Western Ghats between 1000 and 3000 feet elevation. It has been reported from Mettupalayam, the Nadgani Ghats, Mukkali and Silent Valley. It is endemic to south India and the range covers western and southern India, the Nilgiris, Anamalais, Cochin and Travancore.

Hosts: *Bambusa* sp. (Gaonkar, *in prep.*), *Ochlandra* sp.

Status: Endemic, rare, restricted (Gaonkar, 1996).

DISCUSSION

A comparison of external genitalia of species studied:

Species belonging to *Melanitis*, *Lethe*, *Mycalesis*, *Zipaetus*, *Ypthima* and *Elymnias* were studied. Under *Melanitis* two species viz., *M. leda* and *M. (phedima) varaha* were studied. The male genitalia of these species were apparently similar except for the structure of the saccus which was more slender and elongated in the former. The phallus also showed slight differences: more slender and slightly arched in *M. leda* whereas it was stout and more or less straight in *M. (phedima) varaha*.

In *Lethe*, two species were studied viz., *L. (drypetis) todara* and *L. (rohria) neelgheriensis*. The general structure of the male genitalia was more or less the same in both the species although in *L. (rohria) neelgheriensis*, there was a sub-basal, slender, finger-like lobe, one on either side of the uncus. The saccus was relatively short and narrowed basally and the phallus was apically narrowed. In *L. (drypetis) todara*, saccus and the phallus were stouter.

In *Mycalesis*, seven species have been studied viz., *M. anaxias*, *M. perseus*, *M. subdita*, *M. igilia*, *M. adolphei*, *M. patnia* and *M. oculus*. Of these, *M. anaxias*, *M. oculus* and *M. adolphei* showed more resemblance on the basis of valvae which were basally broad and apically narrowed. The latter was quite distinct in possessing valvae with the apical half uniformly narrow, fringed with short hairs and appearing as a distinct lobe. *M. (perseus) tabitha*, *M. igilia* resembled closely in possessing valvae with a wavy margin appearing as curled. In *M. subdita*, valvae were sharply constricted in the middle giving the appearance of two lobes. *M. (Patnia) junonia* also possessed valvae with an uneven margin, but there were two elongate, slender, apically round lobes beset with short hairs, arising from one on either side of the base

of the valvae. With regard to the uncus, excepting *M. (Patnia) junonia*, all species possessed the sub uncus lobes. The saccus also showed difference, being w-shaped in *M. anaxias* and *M. (perseus) tabitha*, V-shaped in *M. subdita*, *M. (Patnia) junonia* and *M. oculus* and handle-shaped with a flat base in *M. igilia* and *M. adolphei*.

Elymnias caudata resembled *M. anaxias*, *M. (perseus) tabitha*, *M. subdita*, *M. igilia* and *M. adolphei* in possessing the sub-uncus lobes. The valvae were however different. In the case of *Ypthima (baldus) madrasa*, the structure was quite different from all the others.

Resemblances in the external genitalia of various species:

Melanitis leda, *M. (phedima) varaha*, *Mycalesis anaxias*, *M. oculus*, *Lethe (drypetis) todara*, *L. (rohria) neelgheriensis* and *Zipaetis saitis* showed resemblance in possessing valvae which were broad in the basal half and narrowed in the distal half. Except for *Melanitis leda*, *M. (phedima) varaha* and *Lethe (drypetis) todara*, all the remaining species resembled in possessing sub-uncus lobes and all these species can be considered as forming one group. Similarly, *Mycalesis (perseus) tabitha* and *M. igilia* showed resemblance in possessing valvae having a wavy margin. These species resembled *L. (rohria) neelgheriensis*, *M. oculus*, *M. (perseus) tabitha*, *M. subdita*, *M. igilia* and *M. adolphei* in possessing sub-uncus lobes. *M. patnia* and *M. subdita* were quite different from the others. Based on an evaluation of resemblances shared by various species, the following species groups were identified:

Group I: Seven species viz., *Melanitis leda*, *M. (phedima) varaha*, *Mycalesis anaxias*, *M. oculus*, *Lethe (drypetis) todara*, *L. (rohria) neelgheriensis* and *Zipaetis saitis* were included under this group. Of these, *Mycalesis anaxias*, *M. oculus* and *L. (rohria) neelgheriensis* formed a subgroup within Group I. *Elymnias caudata* also shared some resemblance to this subgroup.

Group II: *Mycalesis (perseus) tabitha* and *M. igilia* formed a distinct group. These species shared resemblance with *L. rohria*, *Mycalesis oculus*, *M. (perseus) tabitha*, *M. subdita*, *M. igilia* and *M. adolphei*. Each of the species *Mycalesis (Patnia) junonia*, *Mycalesis subdita*, *Ypthima (baldus) madrasa* was quite distinct from all others. Of these, *Y. (baldus) madrasa* stood out separately from all the rest in the structure of valvae, uncus and phallus.

Investigations made in this study have shown that excepting a few, most of the satyrids reported from the southern Western Ghats are well represented in the forests of Kerala. Although most of these are identifiable using colour / wing pattern, the external genitalia morphology will be helpful in confirming their identity especially in cases where seasonal forms occur or when the wing pattern is not clear.

The study has shown clear cut affinities among various species and genera. *Melanitis leda*, *M. (phedima) varaha*, *Mycalesis anaxias*, *M. oculus*, *Lethe (drypetis) todara*, *L. (rohria) neelgheriensis*, *Elymnias caudata* and *Zipaetis saitis* showed overall resemblance on the basis of the morphology of valvae. Among these, *Mycalesis anaxias*, *M. oculus*, *Elymnias*

caudata and *L. (rohria) neelgheriensis* shared some resemblance on the basis of the structure of sub uncus lobes.

With regard to *Mycalesis*, *M. (perseus) tabitha* and *M. igilia* showed more resemblance. These species also showed resemblance to *L. (rohria) neelgheriensis*, *Mycalesis oculus*, *M. (perseus) tabitha*, *M. subdita*, *M. igilia* and *M. adolphei*. Each of the species *Mycalesis patina*, *Mycalesis subdita*, *Ypthima (baldus) madrasa* was quite distinct from all the others. Of these, *Ypthima (baldus) madrasa* stood out separately from all the rest in the structure of valvae, uncus and phallus. Further studies involving all the species will be helpful in bringing out the exact interrelationships of the various taxa.

The morpho-taxonomical analysis carried out in this study has brought out the congeneric nature of various satyrid species. The evolutionary relationships and species boundaries among the satyrine butterflies of Peninsular India may be further clarified by detailed morphological and molecular studies.

Nearly 1500 of butterflies have so far been recorded from the Indian region, of which, about 351 species are known to occur in peninsular India. However, the number of species of butterflies that are exclusively found in the Southern India is only about 45 and most of these butterflies are found in the hilly tracts of the Southern Western Ghats. Of these areas, the latter extending from north of Nagarcoil (Tamil Nadu) to the Palghat Gap is the most important with respect to faunistic diversity with the largest number of species and endemics. Among satyrids, several unique species such as *Mycalesis oculus*, *Ypthima ypthimoides* and *Mycalesis davisoni* are confined to this region. The second region of high diversity is the central Western Ghats, extending north of the Palghat gap from Nilgiri-Waynad area to South Goa. The only butterfly unique to this area is *Mycalesis adolphei*. Information generated in this study has shown very good survival of most of the species mainly due to protection of the natural habitats.

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Biology and morphometry of *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae)

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ABSTRACT: Biology and morphometry studies of *Paracoccus marginatus* Williams and Granara de Willink (Hemiptera: Pseudococcidae) on papaya (*Carica papaya* L.), jatropha (*Jatropha curcus* L.), mulberry (*Morus alba* L.), and potato (*Solanum tuberosum* L.) were carried out in AINPAO laboratory, College of Horticulture, Kerala Agricultural University, Vellanikkara. Among the four host plants, *P. marginatus* on papaya recorded the highest pre-imaginal periods (egg to third instar nymphs in females and egg to pupa in males) for both females and males, whereas the lowest pre-imaginal period was observed on potato. Female *P. marginatus* recorded the highest and lowest adult longevity on papaya and jatropha respectively. The fecundity of *P. marginatus* on the four host plants varied in the order, papaya > potato > jatropha > mulberry. On papaya, mulberry and jatropha, the sex ratio of *P. marginatus* was more male-biased whereas on potato it was slightly female-biased. A non significant variation was observed on morphometrics (length and width) of all stages of male and female *P. marginatus* on four different host plants. © 2013 Association for Advancement of Entomology

KEYWORDS: Papaya mealy bug, *Paracoccus marginatus*, biology, morphometry

INTRODUCTION

Paracoccus marginatus Williams and Granara de Willink (Hemiptera: Pseudococcidae), native to Mexico and Central America (Miller *et al.*, 1999), is an insect pest that attacks several genera of cultivated and non cultivated plants (Miller and Miller, 2002; Mani and Shivaraju, 2012). Muniappan *et al.*, (2008) have for the first time reported the incidence of *P. marginatus* on papaya in Tamil Nadu and later in Kerala (Krishnakumar and Rajan, 2009; Lyla and Philip, 2010; ManiChellappan *et al.*, 2013), Karnataka, Andhra Pradesh, Maharashtra, Tripura and

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Odisha., life history understanding of an insect pest is important in predicting its development, emergence, distribution, abundance (Amarasekare *et al.*, 2008) and for the better methods of management of *P. marginatus*. Not much detailed information was available on biology and morphometry of *P. marginatus* except the studies of Amarasekare *et al.* (2008) and Thangamalar *et al.* (2010). In the present study detailed biology with morphmetrics (length and width) of all stages of male and female *P. marginatus* were carried out on four different host plants and compared.

MATERIALS AND METHOD

Biology and morphometric studies of *P. marginatus* were carried out in All India Network Project on Agricultural Ornithology laboratory, College of Horticulture, Kerala Agricultural University, Vellanikkara, Kerala. Specimens of papaya mealybug used in this study were confirmed to be *P. marginatus* by the insect identification keys provided by Miller and Miller (2002). The host plants used in this study were papaya (*Carica papaya* L.), jatropha (*Jatropha curcus* L.), mulberry (*Morus alba* L.), and potato (*Solanum tuberosum* L.) since they were known to be infested with *P. marginatus* (Mani and Shivaraju, 2012).

Laboratory culture of *P. marginatus* : The laboratory culture of *P. marginatus* was maintained on sprouted potatoes as per Gautam (2008). Cleaned potato sprouts were used as hosts for rearing *P. marginatus*. Potato tubers were thoroughly washed under tap water and air dried. A small incision (7mm depth and 2 cm length) was made on the tubers, opposite to eye sprouts using a sharp sterilized blade. The potatoes were then soaked in gibberellic acid (GA) solution (1 %) for 30 minutes to encourage sprouting and then air dried. After GA treatment, the potatoes were transferred to trays containing wet sterilized sand. The trays were covered with a black muslin cloth to promote rapid sprouting and kept in dark place. Every day the sand was sprinkled with water to maintain moisture. After six days or when the sprouts reached 2.5 – 3.0 cm in length, the potatoes were cleaned and transferred to trays lined with moist tissue paper. Depending on the size of the potato tubers, each sprouted potato was infested with four to five ovisacs of *P. marginatus*. To maintain the colony of *P. marginatus*, for each week, twenty newly sprouted potatoes were infested with ovisacs of PMB.

Life cycle of *P. marginatus* on four different host plants

a. Selection of host plants: The individual leaves of all four host plants with petioles were removed and kept in petri plates lined with moist cotton cannot withstand for about one month even if the base of the petiole is covered with a water soaked cotton swab to prevent desiccation of leaf. Hence, in all the four cases either the whole plant or a plant stump with intact root system was used in the study.

For papaya, three months old seedlings (20 cm height and 4 – 5 leaves) and for mulberry and jatropha, three months old plant stump with intact root system (17.5 cm height and 3 – 5 leaves) were used. In all plants a fully expanded young leaf preferably at the top most position

was selected and all the remaining leaves were removed (Amarasekare *et al.*, 2008). Medium sized potato tubers (100g) with sprouts (3 cm height) were also selected for studying biology of *P. marginatus*. All host plants were maintained inside Mylar cages to prevent any kind of extraneous infestation. Ten replications were made for each host plant to get an unbiased data.

b. Duration of pre-imaginal time of male and female *P. marginatus*: Each host plant was inoculated with eggs of *P. marginatus* (10 eggs per leaf) using a camel hair brush. The eggs used in all replications of a single host plant were collected from a single female within 24 h of oviposition. All plants were observed daily for egg hatch. The interval between each moulting was checked by examining exuvia on the leaves using a hand lens (10 X magnification) and the exuviae were removed after each moult. Morphological determination of all the instars was done under a stereo zoom microscope (Leica[®]) in the laboratory. The number of days to egg hatch, emergence of first instars, duration of second instar males and females, duration of third instar males (pre-pupa) and females and duration of fourth instar males (pupa) were recorded. From this data, the pre-imaginal time of male and female mealybugs (egg to pupa in males and egg to third instars in females) (Zaviezo *et al.*, 2010) were calculated.

c. Generation time and reproductive period: The adult female mealybugs were individually transferred to new petri plates (containing leaves of each host plant lined with moistened cotton) for monitoring the reproductive period (pre oviposition, oviposition and post oviposition periods). From this data the generational time of female mealybugs (egg to oviposition) (Zaviezo *et al.*, 2010) was worked out.

d. Adult longevity, fecundity and sex ratio: To study adult longevity the male and female mealybugs were observed daily until they died. In case, when the host plants have missing number of mealybugs, they were discarded from the experiment. For determining fecundity, number of eggs in ovisacs was counted in five ovisacs taken from each host plant. Sex ratio was calculated by counting the total number of adult males and females in each Petri plates and expressed as ‘male: female’.

Morphometry of *P. marginatus* on four different host plants: All stages of live *P. marginatus* (eggs, first instars, second and third instars of males and females, fourth instar males and adult males and females) (Fig.1) were separated from the rearing colonies on four different host plants and morphometric characters (length and width) were measured using stereo zoom microscope (Leica[®]) with image analyzer facility. Five specimens of each of all stages of male and female *P. marginatus* from four different host plants were taken and a total of 180 specimens were sampled. All measured specimens were then preserved in ethyl alcohol (70 %) for further reference.

RESULTS AND DISCUSSION

Biology of *P. marginatus* on four different hosts: The life cycle study of *P. marginatus* on four different host plants revealed that there were differences in the developmental time of different stages of *P. marginatus* on these plants.

Duration of pre-imaginal time of male and female *Paracoccus marginatus*: Eggs of *P. marginatus* had maximum incubation period on papaya [8.2 ± 0.63 days (d)] and on potato had the minimum (5.11 ± 0.78 d). The hatching period of eggs of papaya mealybug on jatropha and mulberry was 7.3 ± 0.82 and 5.8 ± 0.79 d respectively. The difference in the hatching period of eggs is in accordance with the results obtained by, Amarasekare *et al.*, (2008), Thangamalar *et al.*, (2010), Tanwar *et al.*, (2010), Mishra (2011), Kalaniyangoda *et al.*, (2011) and Suganthy *et al.*, (2012) on different host plants. Studies made by Amarasekare *et al.*, (2008) showed the incubation period was 8.6 ± 0.1 d on acalypha, 8.4 ± 0.1 d on hibiscus, 8.8 ± 0.1 d on parthenium and 8.5 ± 0.1 d on plumeria. Thangamalar *et al.*, (2010) observed at 20 and 25°C temperature gradients eggs hatched in 3 – 4 days and 10 days respectively. Alison *et al.*, (2003) and Tanwar *et al.*, (2010) reported ten days of hatching period for *P. marginatus*. According to Suganthy *et al.*, (2012) the incubation period of papaya mealybug on sunflower under greenhouse and laboratory conditions were 6.3 ± 0.58 and 7.20 ± 1.30 d respectively. The results of Mishra, (2011) (4.8 ± 0.9 d on potato) and Kalaniyangoda *et al.*, (2011) (4 – 7 d on potato) also confirmed the present study result of incubation period of *P. marginatus* on potato.

For the first instar nymphs the shortest duration was seen on potato (3.56 ± 0.53 d) and that on mulberry it was the highest (5.9 ± 0.74 d). First instars on papaya and jatropha almost had same duration (4.6 ± 0.52 and 4.2 ± 0.57 d respectively). According to Amarasekare *et al.*, (2008), among the four host plants (acalypha, hibiscus, parthenium and plumeria) studied by them, first instars on plumeria showed the highest duration (6.6 ± 0.1 d) and parthenium showed lowest duration (5.8 ± 0.1 d). Suganthy *et al.*, (2012) reported first instar larvae of papaya mealybug on sunflower took four days under both greenhouse and laboratory conditions and this is in conformity with the present result of first instars on jatropha and papaya. But, Mishra (2011) reported only 2.6 ± 0.5 days on potato, somewhat a different result.

The duration of second instar male and female nymphs were almost equal on papaya (4.2 ± 0.63 d for females and 4.3 ± 0.67 d for males) and jatropha (3.8 ± 0.42 d for females and 3.6 ± 0.52 d for males). However, on mulberry and potato, there was a difference of approximately one day. On mulberry, females had longer developmental period (5.4 ± 0.52 d) than males (4.7 ± 0.48 d) while on potato males had longer duration (5.22 ± 0.67 d) than females (4.22 ± 0.44 d). But, Amarasekare *et al.*, (2008) reported second instar males had longer developmental period than second instar females. The difference may be due to different host plants.

Third instar females of *P. marginatus* had maximum duration on potato (6.11 ± 0.60 d) and minimum on jatropha (4.7 ± 0.67 d). However, on both papaya (5.1 ± 0.32) and mulberry (5.1 ± 0.88 d), third instar females had almost same duration and in accordance with the result obtained by Suganthy *et al.*, (2012) on sunflower under greenhouse and laboratory conditions (5.00 ± 1.00 and 4.80 ± 0.45 d respectively). The results of Amarasekare *et al.*, (2008) on plumeria (5.1 ± 0.1 d) also support the above result. Amarasekare *et al.*, (2008) also reported duration of third instar females on parthenium was 4.7 ± 0.1 d which again confirmed present result on jatropha. Studies made by Mishra (2011) on potato showed third instar females took 6.30 ± 0.9 d which were in accordance with the present result on potato.

Table 1. Duration of pre-imaginal stage of male and female *P. marginatus*

Life stages of <i>P. marginatus</i>	Host plant species (duration in days)			
	Papaya*	Mulberry*	Jatropha*	Potato**
Egg	8.5±0.85	5.8±0.79	7.3±0.82	5.11±0.78
I instar nymph nymph	4.6±0.52	5.9±0.74	4.2±0.57	3.56±0.53
II instar female nymph	4.2±0.63	5.4±0.52	3.8±0.42	4.22±0.44
III instar female nymph	5.1±0.32	5.1±0.88	4.7±0.67	6.11±0.60
II instar male nymph	4.3±0.67	4.7±0.48	3.6±0.52	5.22±0.67
III instar male (pre-pupa) nymph	2.6±0.52	2.3±0.67	2.3±0.48	2.56±0.53
IV instar male (pupa)	4.2±0.63	4.6±0.52	4.2±0.63	4.78±0.44
Preimaginal phase (duration in days)				
Adult female	22.4±1.35	22.2±1.69	19.9±1.45	19.00±0.86
Adult male	23.9±1.20	23.3±0.82	21.5±1.65	20.67±1.22

*—mean of ten observations, **—mean of nine observations

The developmental time of pre-pupal males on the four host plants were almost identical (2.6 ± 0.52 d on papaya, 2.3 ± 0.67 d on mulberry, 2.3 ± 0.48 d on jatropha and 2.56 ± 0.53 d on potato). Similar trend was seen in duration of pupal males also (4.2 ± 0.63 d on both papaya and jatropha, 4.6 ± 0.52 d on mulberry and 4.78 ± 0.44 d on potato). However, studies of Amarasekare *et al.*, (2008) on different plants (acalypha, hibiscus, parthenium and plumeria) showed that the duration of pupal males on each host plant varied significantly and ranged between 2.6 ± 0.1 and 4.5 ± 0.1 d. Studies made by Suganthy *et al.*, (2012) also showed a varying result of 3.33 ± 0.55 d on sunflower.

On all four host plants studied pre imaginal time period (egg to third instar nymphs in females and egg to pupa in males) was different for both females and males. In all host plants males had longer preimaginal developmental time than females. The longer total preimaginal time for males can be explained mainly by the presence of an additional pupal stage whereas this stage was absent in females. Among the four host plants, *P. marginatus* on papaya had the highest preimaginal time period for both females (22.4 ± 1.35 d) and males (23.9 ± 1.20 d) and that on

potato (19.0 ± 0.86 for females and 20.67 ± 1.22 d for males) had the shortest. On papaya, the longer pre imaginal time of females might be due to longer incubation period and in males it was due to longer egg period and pupal duration. On potato, egg period and first instar stage were shorter as compared to the same stages of *P. marginatus* on other host plants and this account for the shorter pre imaginal period on potato.

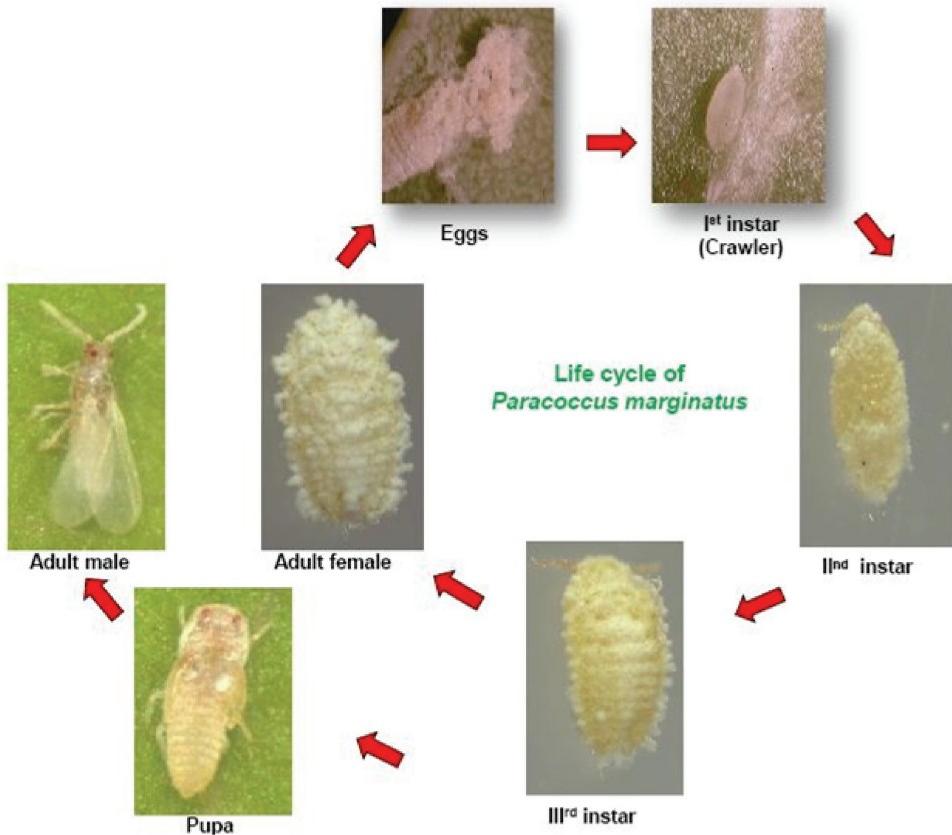


Fig. 1 Life stages of *Paracoccus marginatus*

Generation time and reproductive period: Pre oviposition period of female *P. marginatus* was maximum on potato (5.67 ± 0.71 d) and minimum on jatropha (3.3 ± 0.48 d). On both papaya (4.1 ± 0.57 d) and mulberry (4.0 ± 0.82 d), the period was almost equal. The present study result on potato was supported by the findings of Mishra (2011), who reported 6.4 ± 1.7 d of pre oviposition period for *P. marginatus* on potato. However, according to Amarasekare *et al.*, (2008) *P. marginatus* had 6.8 ± 0.4 and 7.6 ± 0.7 d of pre oviposition period at 25 and 30 °C respectively.

The oviposition period varied between six and eight days depending on the host plant. *P. marginatus* on papaya (7.8 ± 0.63 d) and mulberry (6.4 ± 0.84 d) had maximum and minimum oviposition periods respectively. The oviposition period on jatropha (7.0 ± 0.47 d) and potato (7.12 ± 0.60 d) had almost same duration. Studies made by Suganthy *et al.*, (2012) confirmed the present result. According to them the oviposition period was 7.33 ± 0.58 d on sunflower under greenhouse and 8.20 ± 0.84 d under laboratory conditions. However, the present study results only partially agree with those obtained by Amarasekare *et al.*, (2008), who reported *P. marginatus* had an oviposition time of 11.4 ± 0.8 d at 25°C and 11.6 ± 1.4 d at 30°C .

Table 2. Generation time, adult longevity and total life cycle of *Paracoccus marginatus*

Reproductive periods of <i>P. marginatus</i>	Duration (in days)			
	Papaya*	Mulberry*	Jatropha*	Potato**
Pre oviposition	4.1 ± 0.57	4.0 ± 0.82	3.3 ± 0.48	5.67 ± 0.71
Oviposition	7.8 ± 0.63	6.4 ± 0.84	7.0 ± 0.47	7.12 ± 0.60
Generational phase	34.0 ± 1.15	32.6 ± 2.17	30.3 ± 1.16	31.78 ± 1.64
Adult longevity (duration in days)				
Female	17.6 ± 0.84	13.4 ± 0.84	11.2 ± 0.63	14.22 ± 0.83
Male	2.7 ± 0.48	2.1 ± 0.74	2.0 ± 0.67	2.22 ± 0.44
Total life cycle (duration in days)				
Female	39.7 ± 1.70	35.6 ± 1.78	31.2 ± 1.23	33.22 ± 1.30
Male	26.6 ± 1.07	25.4 ± 0.84	23.6 ± 1.78	23.44 ± 1.23

*—mean of ten observations, **—mean of nine observations

Generation time (pre imaginal developmental period and oviposition period) was four days shorter on jatropha (30.3 ± 1.16 d) than on papaya (34.0 ± 1.15 d). The generational time of mulberry and potato were 32.6 ± 2.17 and 31.78 ± 1.64 d respectively. According to Amarasekare *et al.*, (2008) *P. marginatus* had $24.4 - 25.5$ d of generational time at 25°C depending on the plant. Studies on different species of mealybugs reared on different host plants at 25°C had a longer generational time than *P. marginatus* viz., *Planococcus ficus*(Signoret) (28.1 d on grapevine; Walton and Pringle, 2010), *Maconellicoccus hirsutus* (Green) (32.4 d on hibiscus; Chong *et al.*, 2008), *Planococcus kraunhiae* (Khuwana) (37.8 d on broad bean seeds; Narai

and Murai, 2002) and *Pseudococcus calceolariae* (Maskell) (48.6 d on potato, 56.6 d on lemon and 71.1 d on squash; Zaviezo *et al.*, 2010).

Adult longevity, fecundity and sex ratio: Adult longevity of female *P. marginatus* was significantly higher than males in all host plants. Female adult longevity varied between eleven and eighteen days and host plant dependent whereas in males it was around two or three days and host plant independent. Female *P. marginatus* on papaya had the highest adult longevity (17.6 ± 0.84 d) and that on jatropha it was the lowest (11.2 ± 0.63 d). Adult longevity of female *P. marginatus* on mulberry and potato were 13.4 ± 0.84 and 14.22 ± 0.83 d respectively. The results were supported by the findings of Suganthy *et al.*, (2012) on sunflower. According to them adult longevity of female *P. marginatus* on sunflower was 20.33 ± 1.53 d under greenhouse and 21.20 ± 2.77 d under laboratory conditions. Adult longevity of *P. marginatus* was almost similar to that determined by Chong *et al.*, (2008) on *Maconellicoccus hirsutus*, where in *M. hirsutus* female lived for 21 days and males merely 2.5 days at a temperature between 25 and 30°C. However other species had a greater longevity than *P. marginatus*. In *Pseudococcus calceolariae* female adult longevity was 31.3 ± 1.2 d and in males, it was 5.6 ± 0.4 d (Zaviezo *et al.*, 2010) whereas in *Planococcus kraunhiae* adult females had 25 days of longevity (Narai and Murai, 2002).

Table 3. Fecundity and sex ratio of *P. marginatus*

Host plant	Fecundity* (no.of eggs)	Sex Ratio (♂ : ♀)**
Papaya	442.6 ± 28.98	1.04:1
Mulberry	318.8 ± 16.36	2.03:1
Jatropha	350.6 ± 23.04	1.63:1
Potato	375.4 ± 13.01	0.89:1

*—mean of five observations, **—mean of ten observations

The total life cycle of *P. marginatus* varied greatly depending on the host plant and females had longer total developmental time than males. Females showed maximum life cycle duration on papaya (39.7 ± 1.70 d) mainly due to longer adult longevity whereas those on jatropha it was the shortest (31.2 ± 1.23 d). The total life cycle on mulberry and potato were 35.6 ± 1.78 and 33.22 ± 1.30 d respectively. In all host plants, total developmental time for males varied only slightly i.e., between 23.44 ± 1.23 and 26.6 ± 1.07 days. These are in agreement with the results of Suganthy *et al.*, (2012) on sunflower, who reported a total life cycle of 39.33 ± 2.53 d for females and 24.00 ± 1.73 d for males under green house conditions. Substantial works has been

conducted and reported by various authors on the total life cycle of males which further confirmed our result (acalypha: 28.4 ± 0.1 d, hibiscus: 27.6 ± 0.1 d, parthenium: 27.7 ± 0.1 d and plumeria: 30.0 ± 0.1 d, Amarasekare *et al.*, 2008; males took 27-30 days Tanwar *et al.*, 2010).

The fecundity of *P. marginatus* on the four host plants varied in the following order: papaya (442.6 ± 28.98)> potato (375.4 ± 13.01)>jatropha (350.6 ± 23.04)>mulberry (318.8 ± 16.36). Several workers opined that *P. marginatus* usually lay 100 to 600 eggs in an ovisac (Miller and Miller, 2002; Walker *et al.*, 2006; Tanwar *et al.*, 2010; Kalaniyangoda *et al.*, 2011). Sharma *et al.*, (2013) reported a female papaya mealybug laid 200-500 eggs in an ovisac. The result was also supported by the findings of Suganthy *et al.*, (2012), who reported the fecundity was 329.33 ± 20.03 and 380.0 ± 28.66 on sunflower under greenhouse and laboratory conditions respectively. According to Amarasekare *et al.*, (2008) the fecundity ranged between 82.0 ± 11.7 (30°C) and 300.2 ± 40.4 (25°C) depending upon the temperature gradient.

In three host plants [papaya ($1.04\delta:1\varphi$), mulberry ($2.03\delta:1\varphi$) and jatropha ($1.63\delta:1\varphi$)] the sex ratio of *P. marginatus* was more male-biased while on potato ($0.89\delta:1\varphi$) the sex ratio was slightly female-biased. According to Amarasekare *et al.* (2008) among the four host plants (acalypha, hibiscus, parthenium and plumeria) studied by them, the sex ratio of adults emerging on plumeria was more female-biased than on the other three hosts. The mean proportion of adult females ranged from 53 to 59 per cent.

The differences observed in the life history parameters of *P. marginatus* might be due to different host plant varieties. According to Amarasekare *et al.*, (2008) nutritive factors, allelochemical compounds, physical differences in leaf structures, etc. affected the life cycle of *P. marginatus*, although none of these factors were studied in depth. The life history parameters of other mealybug species were also found to be affected by different host plant species. Mortality of *Planococcus citri* (Risso) was higher on green than on red or yellow variegated *Coleus blumei* 'Bellevue' (Bentham) plants whereas faster development and higher fecundity was shown by red variegated plants (Yang and Sadof, 1995). Similarly, the developmental time of female *Planococcus kraunhiae* (Kuwana) was shorter when reared on germinated *Vicia faba* L. seeds than on leaves of *Citrus* sp. L. and on *Cucurbita maxima* Duchesne (Narai and Murai, 2002).

Morphometry of *Paracoccus marginatus* on four different host plants

Variations existed with regard to morphometry (length and width) of all stages of male and female *P. marginatus* on four different host plants (Table 4), however, the variations were not significantly different.

Egg : The eggs were translucent, oblong in shape and greenish yellow in colour. The eggs were laid in an ovisac, developed on the ventral side of the adult female mealybug. The eggs on papaya and potato showed same length (0.34 ± 0.01 mm) but different width (0.15 ± 0.01 on papaya and 0.13 ± 0.01 mm on potato). However, the length and width of eggs on jatropha and

mulberry were almost identical (0.31 ± 0.04 and 0.13 ± 0.01 mm on jatropha and 0.31 ± 0.02 and 0.12 ± 0.01 mm on mulberry respectively). Similar results were obtained by Kalaniyangoda *et al.*, (2011) on potato.

First instar nymph: Freshly emerged first instar nymphs were oblong in shape and light yellow in colour with three pairs of legs and a pair of six segmented antennae. Similar to eggs of *P. marginatus*, the length and width of first instar nymphs were also same on papaya (0.42 ± 0.08 and 0.21 ± 0.02 mm respectively) and potato (0.42 ± 0.02 and 0.21 ± 0.01 mm respectively). However, length and width of first instars on jatropha (0.39 ± 0.04 and 0.17 ± 0.02 mm respectively) and mulberry (0.36 ± 0.06 and 0.18 ± 0.01 mm respectively) were less than that on papaya and potato. These results were in accordance with the results of Miller and Miller (2002), Kalaniyangoda *et al.*, (2011) and Al Hilal *et al.*, (2012) on different hosts. According to Miller and Miller (2002), the slide mounted length and width of first instar nymphs of *P. marginatus* were 0.4 mm (0.3 – 0.6) and 0.2 mm (0.2 – 0.3) respectively. Al Hilal *et al.*, (2012) also reported first instar nymphs were 0.42 ± 0.074 mm long and 0.27 ± 0.024 mm wide on papaya.

Second instar: In general appearance and morphological features the second instar nymphs were similar to first instars except in size. They secreted white waxy powder on the dorsal side of the body after about 24 hours of first moult. The sexes of individual mealybugs could be determined during the later part of the second instars as males changed their colour from yellow to pink (Amarasekare *et al.*, 2008). As a result, from this stage onwards the morphometrics of male and female *P. marginatus* were taken separately.

Second instar female nymph: Second instar nymphs intended to become females were oblong shaped and yellow coloured. They had six segmented antennae. The morphometrics of second instar females on four host plants showed variation ie., second instar female nymphs on jatropha had maximum length (0.75 ± 0.15 mm) and minimum (0.69 ± 0.01 mm) on potato whereas those on papaya had the maximum width (0.46 ± 0.05 mm) and minimum width on potato (0.34 ± 0.04 mm). The length and width of second instar nymphs on mulberry were 0.74 ± 0.05 and 0.36 ± 0.01 mm respectively. Our observations in confirmation with the views of Miller and Miller (2002) and Al Hilal *et al.*, (2012). Studies made by Kalaniyangoda *et al.*, (2011) also showed similar results on potato (0.6 ± 0.05 and 0.4 ± 0.08 mm length and width respectively).

Third instar female nymph: Third instar nymphs of females were also oblong in shape with yellow in colour having six or seven segmented antennae. Third instar females on four host plants showed significant variation in their length and width compared to all other stages. The length and width of third instar females varied in the following order: papaya (1.23 ± 0.18 and 0.64 ± 0.05 mm) > jatropha (1.19 ± 0.19 and 0.63 ± 0.04 mm) > mulberry (1.04 ± 0.19 and 0.54 ± 0.03 mm) > potato (0.90 ± 0.02 and 0.45 ± 0.03 mm). According to Miller and Miller (2002) the length of third instar females ranged between 0.7 and 1.8 mm and width between 0.3 and 1.1 mm. Al Hilal *et al.*, (2012) observed a length of 0.89 ± 0.11 mm and width of 0.51 ± 0.02 mm for third instar females of *P. marginatus* on papaya.

Adult female : Adult females of *P. marginatus* had yellow coloured body, dusted with white mealy wax and eight segmented antenna. Adult females also showed noticeable variation among different host plants. Adult females on papaya had maximum body size (2.47 ± 0.17 long and 1.55 ± 0.13 mm wide) and that on mulberry it was the minimum (2.03 ± 0.07 long and 1.01 ± 0.07 mm wide). The length and width of third instar females on jatropha were 2.12 ± 0.11 and 1.26 ± 0.06 mm respectively and that on potato were 2.38 ± 0.05 and 1.32 ± 0.08 mm respectively. Studies made by Miller and Miller (2002) showed the length of adult females ranged between 1.5 and 2.7 mm and width between 0.9 and 1.7 mm. Similar results were obtained by Kalaniyangoda *et al.*, (2011) on potato and Al Hilal *et al.*, (2012) on papaya. Walker *et al.*, (2006), Tanwar *et al.*, (2010) and Sharma *et al.*, (2013) also reported that the adult female of *P. marginatus* body was about 2-3 mm long and 1.4 mm wide.

Table 4. Morphometrics of life stages of *P. marginatus* on four different host plants

Life stages of <i>P. marginatus</i>	Morphometrics of life stages of <i>P. marginatus</i> *							
	Papaya		Mulberry		Jatropha		Potato	
	Length (mm)	Width (mm)	Length (mm)	Width (mm)	Length (mm)	Width (mm)	Length (mm)	Width (mm)
Egg	0.34 ± 0.01	0.15 ± 0.01	0.31 ± 0.02	0.12 ± 0.01	0.31 ± 0.04	0.13 ± 0.01	0.34 ± 0.01	0.13 ± 0.01
I instar nymph	0.42 ± 0.08	0.21 ± 0.02	0.36 ± 0.06	0.18 ± 0.01	0.39 ± 0.04	0.17 ± 0.02	0.42 ± 0.02	0.21 ± 0.01
II instar female nymph	0.72 ± 0.02	0.46 ± 0.05	0.74 ± 0.05	0.36 ± 0.01	0.75 ± 0.15	0.35 ± 0.02	0.69 ± 0.01	0.34 ± 0.04
III instar female nymph	1.23 ± 0.18	0.64 ± 0.05	1.04 ± 0.19	0.54 ± 0.03	1.19 ± 0.19	0.63 ± 0.04	0.90 ± 0.02	0.45 ± 0.03
Adult female	2.47 ± 0.17	1.55 ± 0.13	2.03 ± 0.07	1.01 ± 0.07	2.12 ± 0.11	1.26 ± 0.06	2.38 ± 0.05	1.32 ± 0.08
II instar male nymph	0.75 ± 0.02	0.44 ± 0.02	0.72 ± 0.04	0.35 ± 0.03	0.73 ± 0.14	0.37 ± 0.02	0.65 ± 0.07	0.36 ± 0.04
III instar male nymph (pre-pupa)	0.97 ± 0.12	0.44 ± 0.06	0.90 ± 0.03	0.40 ± 0.01	0.93 ± 0.05	0.42 ± 0.02	0.86 ± 0.04	0.36 ± 0.02
IV instar male nymph (pupa)	0.95 ± 0.04	0.42 ± 0.02	0.94 ± 0.05	0.38 ± 0.01	0.91 ± 0.07	0.39 ± 0.04	0.91 ± 0.06	0.36 ± 0.04
Adult male	0.96 ± 0.03	0.25 ± 0.04	0.97 ± 0.01	0.23 ± 0.01	0.96 ± 0.05	0.24 ± 0.01	0.93 ± 0.01	0.22 ± 0.01

* — mean of five observations

Second instar male nymph: The nymphs were usually pink in colour but occasionally yellow coloured with six segmented antenna. Among the four host plants, the length of second instar males were almost the same on three hosts (0.75 ± 0.02 on papaya, 0.73 ± 0.14 on jatropha and

0.72 ± 0.04 mm on mulberry) with the exception on potato (0.65 ± 0.07 mm). Likewise the width of second instar males also showed similarity on jatropha (0.37 ± 0.02 mm), potato (0.36 ± 0.04 mm) and mulberry (0.35 ± 0.03 mm). However, second instar males on papaya was wider (0.44 ± 0.02 mm) than all other host plants. The morphometric characters of second instar males of papaya mealybug studied by Miller and Miller (2002), who reported the length of second instar male nymphs ranged between 0.5 and 1 mm and width between 0.2 and 0.6 mm. Al Hilal *et al.*, (2012) also reported a length of 0.6 ± 0.05 mm and width of 0.4 ± 0.09 mm for second instar male nymphs.

Third instar male nymph (pre-pupa): Third instar males were also pink coloured and oblong shaped. Antennae were present without definite segmentation (Miller and Miller, 2002). The length and width of third instar males varied in the following order: papaya (0.97 ± 0.12 and 0.44 ± 0.06 mm) > jatropha (0.93 ± 0.05 and 0.42 ± 0.02 mm) > mulberry (0.90 ± 0.03 and 0.40 ± 0.01 mm) > potato (0.86 ± 0.04 and 0.36 ± 0.02 mm). These results were in conformity with the results of Miller and Miller (2002) on papaya (0.9 mm long and 0.4 mm wide) and Al Hilal *et al.*, (2012) on potato (1.05 ± 0.23 mm long and 0.59 ± 0.16 mm wide).

Fourth instar male (pupa): Male cocoons were cylindrical in shape and white in colour. Pupae had ten segmented antennae. Fourth instar males or pupal males on jatropha (0.91 ± 0.07 mm) and potato (0.91 ± 0.06 mm) had the same length and that on papaya (0.95 ± 0.04 mm) and mulberry (0.94 ± 0.05 mm) also showed almost same length. Similarly, on jatropha (0.39 ± 0.04 mm), mulberry (0.38 ± 0.01 mm) and potato (0.36 ± 0.04 mm) almost had same width. Similar morphometric characters were explained by Miller and Miller (2002) and Al-Hilal *et al.*, (2012).

Adult male: Adult males of *P. marginatus* were elongate and oval in shape, having greatest width at the thorax. They had ten segmented, bristle shaped antennae and appeared to be much longer than that of female antennae. Adult males on mulberry showed maximum length (0.97 ± 0.01) and that on potato it was minimum (0.93 ± 0.01 mm) while adult males on both of these plants almost had same width (0.23 ± 0.01 and 0.22 ± 0.01 mm respectively). However, adult males on papaya and jatropha showed similar length (0.96 ± 0.03 on papaya and 0.96 ± 0.05 mm on jatropha) and width (0.25 ± 0.04 on papaya and 0.24 ± 0.01 mm on jatropha). The results were in conformity with the results of Miller and Miller (2002) on papaya (1 mm length and 0.3 mm width), Kalaniyangoda *et al.*, (2011) on potato (0.9 mm long and 0.20 mm wide) and Al Hilal *et al.*, (2012). Walker *et al.*, (2006), Galaniche *et al.*, (2010), Tanwar *et al.*, (2010) and Sharma *et al.*, (2013) also reported adult males of *P. marginatus* were 1 mm long and 0.3 mm wide.

It was found that there exists variations in the body size of male and female *P. marginatus* in all the four host plants. According to Umbarihowar and Hastings (2002) host plants played an important role in regulating insect population. Yang and Sadof (1995) reported that variegation in *Coleus blumei* (Benth.) could increase the abundance of citrus mealybug, *Planococcus citri*. Hence, we could concluded that the difference observed in the morphometry of different stages of male and female *P. marginatus* might be due to the nutritive factors, allelochemical compounds present in the host plants, nutritional quality of food, and leaf nitrogen concentration (Hogendorp *et al.*, 2006), rearing conditions, etc.

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Report of orchid mite, *Tenuipalpus pacificus* Baker (Prostigmata: Tenuipalpidae) from Kerala, India

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ABSTRACT: Incidence of *Tenuipalpus pacificus* Baker, a mite species, was recorded on an orchid. This is the first report from India. The mite species would probably have gained entry into India through imported planting materials of hybrid orchids. © 2013 Association for Advancement of Entomology

KEY WORDS: *Tenuipalpus pacificus* Baker, a mite species, *Phalaenopsis* Blume, orchid

Orchids are the most popular ornamental and flowering plants world over. In India, all tropical orchids can be successfully grown and hence many commercial ornamental nurseries are involved in large scale production and sale of orchid plants. States of Kerala, Tamil Nadu, Karnataka, Goa, Maharashtra, Andhra Pradesh, Odisha, West Bengal, Assam, Arunachal Pradesh, Sikkim etc. are identified as potential areas for commercial orchid cultivation. Commercial nurseries here import hybrid orchids from South East Asian Countries. Species of *Phalaenopsis* are among the most popular orchids sold in India as potted plants owing to the ease of propagation and flowering under artificial conditions. *Phalaenopsis* Blume, represented by about over 40 species, is a tropical Asiatic genus mainly distributed in Indonesia and the Philippines (Seidenfaden and Wood, 1992). Among the Southern states of India, Kerala is most suited for cultivation of almost all the tropical orchids and it is one of the leading states in commercial orchid cultivation in India. The *Phalaenopsis* orchid, commonly called as “moth

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Plate 1. Symptom of flat mite infestation



Plate 2. *Tenuipalpus pacificus* Baker

orchid" has become increasingly popular in commercial orchidariums in Kerala in recent years, where hybrid orchids imported from South East Asian Countries are on high demand.

During 2011, heavy incidence of a flat mite belonging to the genus *Tenuipalpus* was reported on *Phalaenopsis* orchid from different ornamental plant nurseries of Thrissur District, Kerala, India (Binisha and Bhaskar, 2011). Subsequently, a detailed survey was undertaken in some commercial orchidariums and homestead gardens located in Madakkathara and Vengitangu Panchayath in the district during the summer months of March – April, 2012 and incidence of flat mites belonging to the family Tenuipalpidae was confirmed. The mites are crimson in colour, flat bodied with short legs and are less active. They were found colonizing the lower surface of *Phalaenopsis* leaves causing dark patches leading to necrosis of tissues (Plate 1). Mite samples on *Phalaenopsis* leaves were collected and preserved in 70 per cent alcohol for further taxonomic studies. The mites were mounted on slides with Hoyer's medium and taxonomic studies were carried out. The mite was identified as *Tenuipalpus pacificus* Baker.

T. pacificus (Plate.2) can be distinguished by the following characters: Podosoma distinctly broad and opisthosoma narrow; dorsal ornamentation on the body with only a few longitudinal striae, two pairs of anterior medioventral metapodosomal setae with the inner pair shorter than the outer pair; two pairs of posterior medioventral metapodosomal setae with the inner pair much longer than the outer pair; one pair of ventral plate setae; two pairs of genital plate setae; first two pairs of propodosomal setae about half as long as the third pair and about equal in size as the hysterosomal posterior marginal setae; posterior margin of hysterosoma with one pair of not so long flagellate setae.

T. pacificus reported as a pest of different species of orchids and some ferns from different parts of the world (Jeppson *et al.*, 1975; Ghai and Shenhmar, 1984 and Mesa *et al.*, 2009). However, the mite was not recorded on orchids earlier from India. This is the first record of *T. pacificus* on an orchid from India. The mite species would probably have gained entry into India through imported planting materials of hybrid orchids.

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An unusual aberration of the hindwing veins in *Luxiaria amasa* (Butler) (Lepidoptera: Geometridae: Ennominae) with a note on female external genitalia

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ABSTRACT: Aberration of the hindwing veins in *Luxiaria amasa* (Butler) of family Geometridae is presented along with the description of its external genitalia. The tips of hind wing veins are spatulate and this type modification is rather rare in Lepidoptera. © 2013 Association for Advancement of Entomology

KEYWORDS: Lepidoptera, Geometridae, Ennominae, *Luxiaria amasa* (Butler), unusual vein endings.

Genus *Luxiaria* was established as a monotypic genus by Walker in 1860 for its type species *Luxiaria alfenusaria* Walker from Borneo and presently is known by 41 species and 11 subspecies from all over the world (Scoble, 1999). *Luxiaria* Walker is distributed throughout the Oriental and Palearctic region and is diagnosed on the following characters: ciliated male antennae, hind wing margins are rounded and generally crenulated, male genitalia with subapical processes or flanges on ventral arm of valve, uncus strongly bilobed with a dorsal spur set within the cleft between lobe, aedeagus vesica has a lateral digitate lobe that terminates in a single cornutus (Holloway, 1993). The members of *Luxiaria* Walker were collected with the help of vertical sheet light traps from the localities mentioned in the material examined. The collected moths were processed as per standard techniques in Lepidopterology. The identification was done with the help of relevant literature (Hampson, 1895; Scoble, 1999). For the study of wing venation and external male and female genitalia Comstock (1918), Kukalova (1978, 1983) and Klots (1970) has been followed.

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While making a study of the geometrid genus *Luxiaria*, an unusual type of aberration was noticed in the shape of hind wing veins of *Luxiaria amasa* (Butler). Usually, the vein endings are simple however, in this species each of the hindwing vein ends into a flat and spatulate structure. This condition has not been so far reported in any other Lepidopteran species. As the male genitalia of *Luxiaria amasa* (Butler) has been studied in detail by Holloway (1993), the morphological details of the female genitalia are studied and the description is given below.

Luxiaria Walker, 1860

Luxiaria Walker, 1860, *List spec. lipid. Insects Colln Br. Mus.* **20**: 231.

Type species: *Luxiaria alfenusaria* Walker

Luxiaria amasa (Butler)

Bithia amasa Butler, 1878, *Ann. Mag. nat. Hist.* (5) **1**: 405.

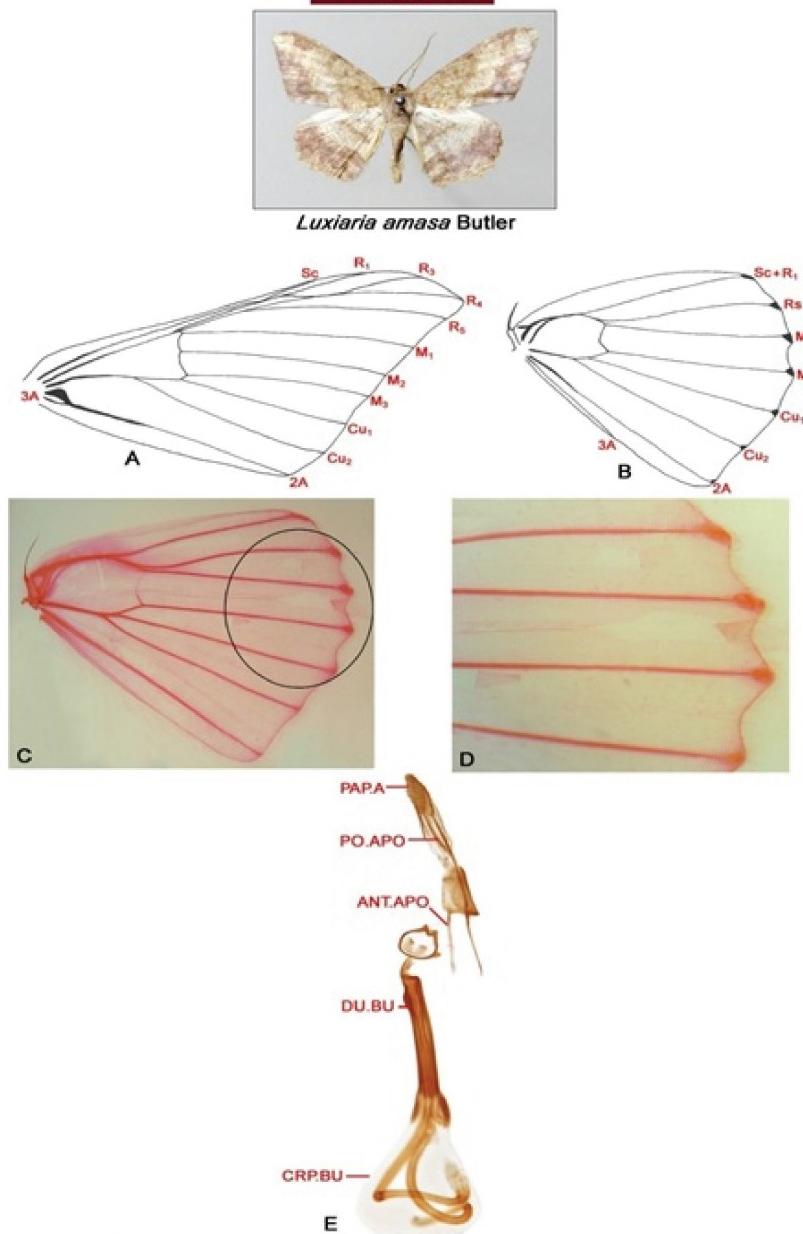
Diagnosis: The species can be identified from its pale yellow ground colour with irroration of dark brown scales on head, thorax, abdomen and basal and terminal portion of wings. Forewing with vein R_1 anastomoses with Sc and then with stalk of R_3 and R_4 , vein R_2 absent, R_3-R_5 stalked from upper angle of cell and hindwing with vein $Sc+R_1$ connected with cell at middle, vein Rs rising from before upper angle of cell. Hind tibiae of male dilated with a longitudinal fold containing a ridge of silken hairs with two pair of spurs. **Male Genitalia** as in genus. **Female Genitalia** with corpus bursae conical flask like, long and sclerotized, tube like towards ductus bursae, signum absent; ductus bursae small, tube like; anterior apophysis almost equal to posterior apophysis, sclerotized; ostium bursae ring shaped; papilla anales elongated, setosed.

Wing Span: Male: 27mm; Female: 26mm.

MATERIAL EXAMINED: Arunachal Pradesh: Dirang, 1500m, 7.x.10- 1♂, 2♀; Bomdila, 2530m, 9.x.10, 1♂; Hunli, 1460m, 19.ix.11-2♂, 1♀. Mizoram: Thingsul, 850m, 18.ix.09- 1♂

Abbreviations

ANT.APO	:	Anterior apophyses	M_3	:	Third median vein
CRP.BU	:	Corpus bursae	PAP.A	:	Papila anales
CU_1	:	First cubital vein	PO.APO	:	Posterior apophyses
CU_2	:	Second cubital vein	R_1	:	First radial vein
DU.BU	:	Ductus bursae	R_2	:	Second radial vein
M_1	:	First median vein	R_3	:	Third radial vein
M_2	:	Second median vein	R_4	:	Fourth radial vein

FIG. 1

A. Forewing (Line Diagram), **B.** Hindwing (Line Diagram), **C.** Hindwing (Photographed), **D.** Hindwing vein endings (Enlarged), **E.** Female genitalia.

R_5	:	Fifth radial vein	2A	:	Second anal vein
Rs	:	Radial Sector	3A	:	Third anal vein
SC	:	Sub costa			

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